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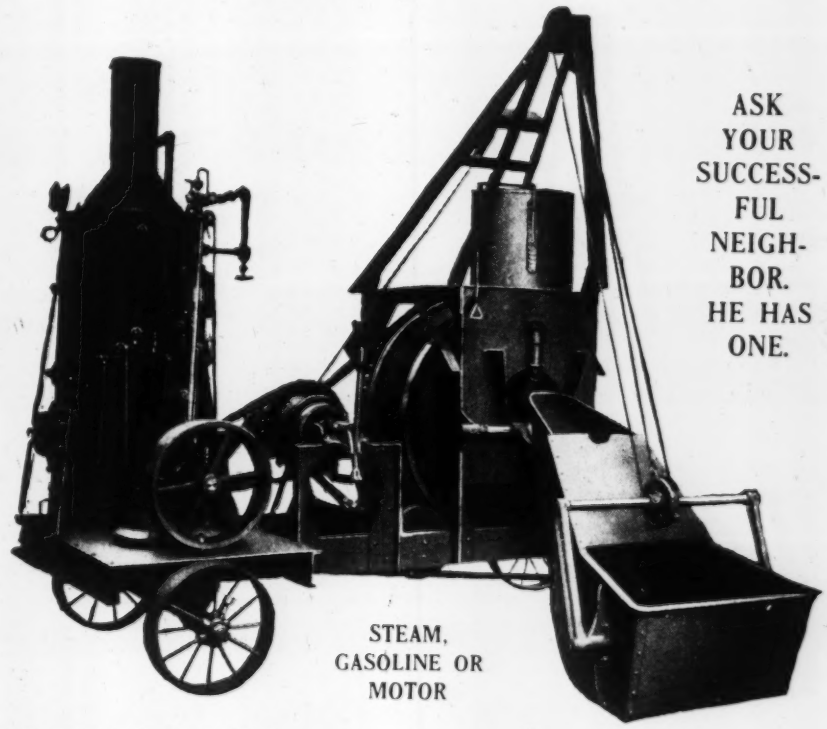

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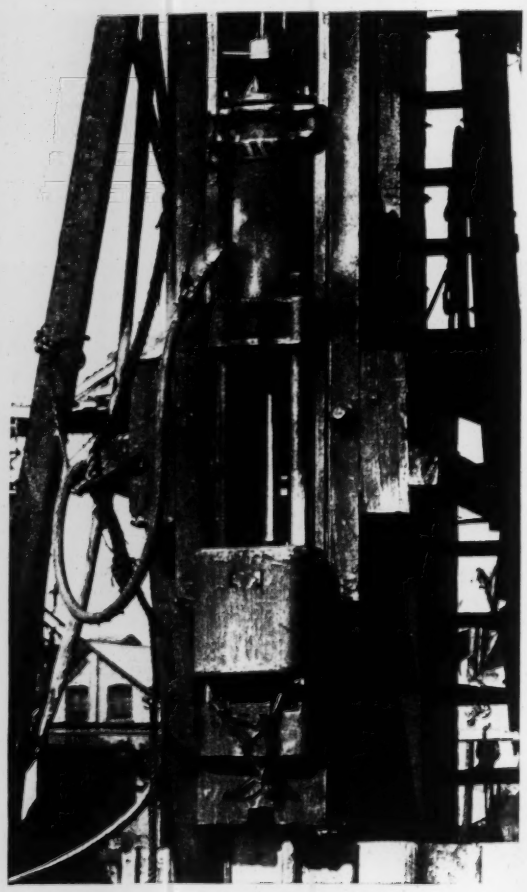

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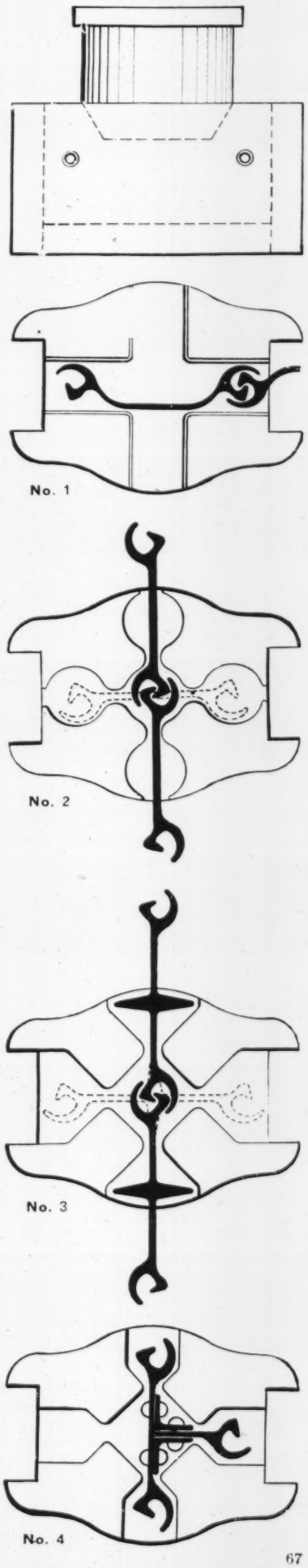

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Engineering News

CHARLES WHITING BAKER, *Editor*

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Number Fifteen

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Engineering News

VOLUME 69 APRIL 10, 1913 NUMBER 15

Philippine Road Maintenance Problems*

The accompanying illustration shows a view of Bued Cañon and the Benguet Road on the Island of Luzon, P. I., about 125 miles north of Manila. At this place the road climbs 845 ft. in a distance a trifle less than two miles. The road is much used by automobile trucks for both freight and passenger service between the nearest railway and the city of Baguio, which has become quite a health resort. The automobile bus line over this road carried over 19,000 passengers in the year 1911-1912, but the railway is now being extended to Baguio, which will materially decrease the importance of the Benguet Road.

In July, 1911, the Bued Cañon was visited by an extraordinary storm, during which 46 in. of rain fell in a single day and 88 in. in four days. This unprecedented rainfall, falling on the bare, precipitous sides of the cañon, with its disintegrated and unstable earth and rock covering, resulted in extensive damage to the road: for, although the upper half of the road stood the flood remarkably well, great destruction was done on the lower part by two enormous landslides, the contents of which were estimated at nearly 2,000,000 cu.yd.

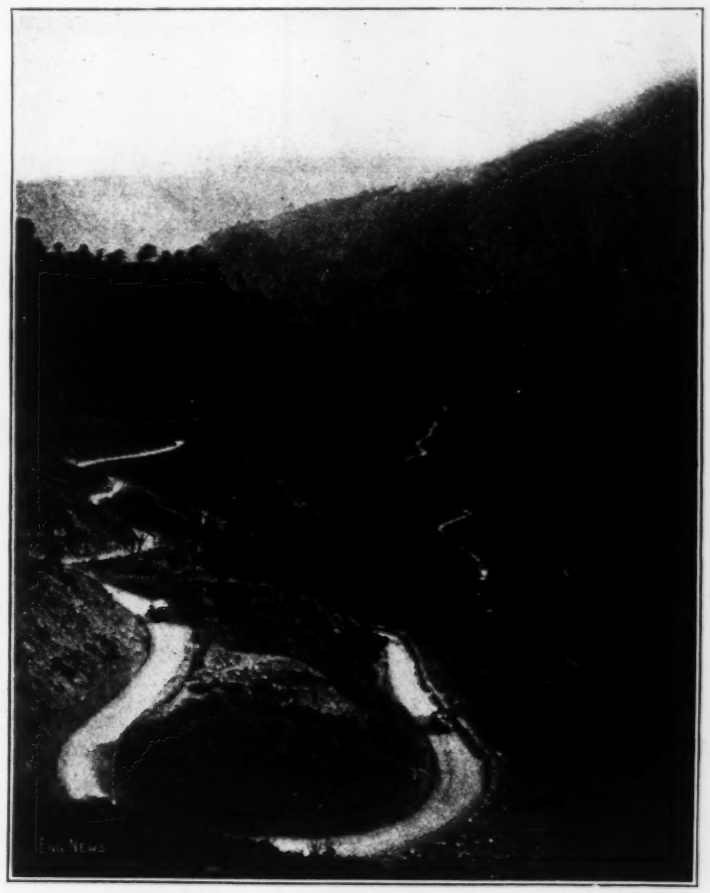
These two slides formed a natural dam across the cañon 150 ft. high, behind which a great volume of water collected until the dam was overtopped. During the few hours this dam existed, sand and gravel were deposited for a distance of several miles above the dam to a depth of 40 to 50 ft. above the former river bed. The bursting of this dam let loose a tremendous flood, which swept down the cañon, tearing out a steel highway bridge and doing great damage to the lower part of the road. The city of Baguio was cut off from all communication for eight days, and then a temporary trail was opened from the west side of the city.

The reconstruction of the road seemed doubtful for a time. Several miles of the roadbed had disappeared under the vast deposit of gravel and boulders, and the construction of a new road higher up on the mountain side was believed to be a financial impossibility for the provincial government.

While the authorities were debating what measures should be taken, another extraordinary rainfall came in September, when 31 in. of rain fell in 24 hours. This flood cut through the great gravel deposit and swept a large part away, making it possible to reconstruct a road more or less on the same location as the old road. The reconstruction work was started in October and completed so that automobile trucks could use the road by Dec. 22, 1911. The cost was about $50,000. The view shown is from a photograph taken in June, 1912. The engineer in charge was Will Arthur.

The yearly maintenance charge for this road (about 20 miles long) for the previous five years had varied from $82,000 to $180,000, including also contributions for the maintenance of the central organization of the Bureau of Public Works and road improvements.

With the opening of the railway into Baguio, the traffic on the road will drop off to such an extent that the cost



VIEW OF THE BENGUET ROAD, BUED CANYON, ISLAND OF LUZON, PHILIPPINE ISLANDS, JUNE, 1912

of maintenance will be much lessened; for a considerable portion of the cost of maintenance is not due to floods, but to the exceedingly heavy traffic and to the necessity for rush work and expensive work to keep the road in condition for traffic during the rainy season.

The automobile line operates 18 trucks, which have a carrying capacity of two tons each. The rates charged for passengers, baggage and freight are much lower than were formerly charged when the traffic was handled by mule teams and bullock carts.

*From data contained in the recently issued Annual Report of the Director of Public Works, for the year ending June 30, 1912; Manila, P. I.

A Coffer-Dam on Sand Bottom; Ohio River Dam No. 48*

By J. C. Oakes†

Of the 54 dams proposed for the canalization of the Ohio River all of those thus far built or contracted for, except No. 48, at mile 804½, or 6 miles below Henderson, Ky., have fairly firm foundations, most of them being on rock and a few on gravel. The material at all lock sites above Louisville is supposed to be of a character that will not be easily eroded by the current, so that up to the present time no special precautions have had to be taken for protection of coffer-dams during construction or for protection of the works against undermining by the current after completion and during operation.

Below Louisville, however, a totally different type of foundation is encountered. In the 13 dams to be constructed in the lower 400 miles of the river, rock is found at the sites of only three; elsewhere foundations are fine sand and silt, so fine that the bottom changes with every stage of the river. This fact has caused considerable anxiety, not only with reference to the planning of the works to insure stability after completion, but particularly with reference to the danger to the coffer-dams and erosion of the bed of the river during the period of construction. It has been openly affirmed by some of the contractors who have had experience on the Ohio River that it would be impossible to construct coffer-dams in the shifting sands of the lower river that would remain during the period of construction, and, second, that if constructed, they could not be made sufficiently impervious against seepage to withstand the ordinary pressure heads, and that they could not be pumped out sufficiently to enable the work to proceed.

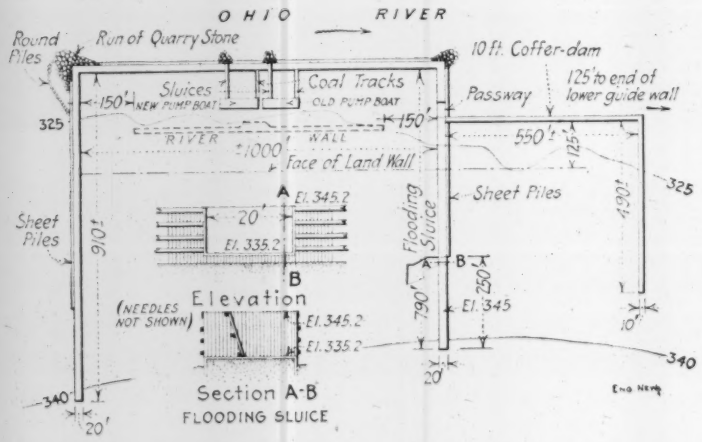
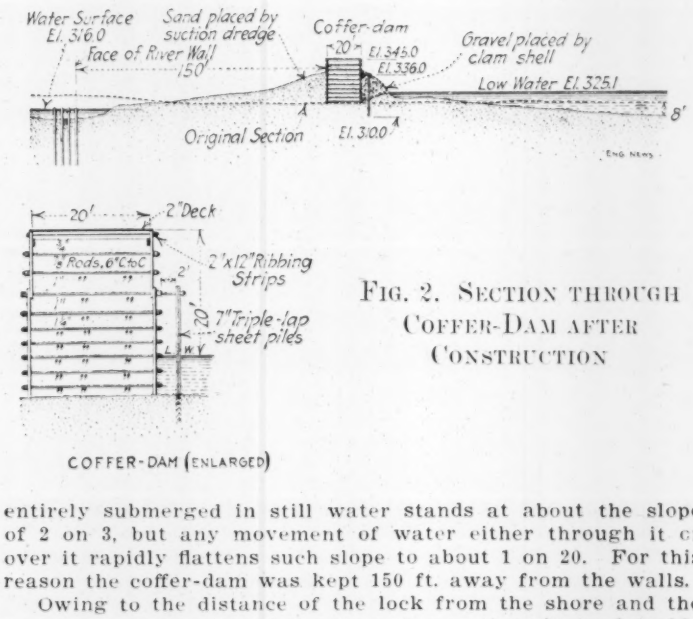


FIG. 1. PLAN OF COFFER-DAM FOR DAM 48, OHIO RIVER



COFFER-DAM (ENLARGED)

FIG. 2. SECTION THROUGH COFFER-DAM AFTER CONSTRUCTION

At the site selected for dam No. 48, the width between low water lines is 1600 ft.; between 20-ft. contours, 3100 ft. The lock is to be located on the convex shore of a bend in the river, the radius of which is approximately 4000 ft. Low water is at elevation 325 (Sandy Hook datum), with high water (1884) at 373. The flood of January, 1913, at this site almost equaled that of 1884, reaching an elevation of 371. The lock is to be constructed on the Indiana side where the general level of the banks is at elevation 360. On the Kentucky side the bank is somewhat higher, being approximately at 380. The river wall of the lock is to be approximately along the line of low water, which places that wall some 700 ft. from the contour of the bank corresponding to that of the elevation of the top of the walls. The terreplein between gate recesses is to be connected with the river bank by a causeway or dike at a general elevation of the top of the land wall.

The lock is the standard size adopted for the river, 600x110 ft., with lift of 9 ft. The dam is to have a navigable pass 800 ft. wide with Chanoine wickets 16 ft. 5 in. long; a Chanoine weir 600 ft. wide, wickets 11 ft. 9 in. long, and a permanent weir 890 ft. long, the elevation of whose crest is to be 1 ft. below upper pool, or 337. Upper pool is at 338, lower pool 329, top of river wall 341, and top of land wall 343.

The material found at the site is a fine sand and silt intimately mixed, with an occasional pocket of very fine gravel. In driving a few long piles to a depth of 47 ft. below low water some difficulty was experienced and it is supposed that a layer of gravel was encountered, but no borings have been taken to verify this. This material when quite dry or when entirely submerged in still water stands at about the slope of 2 on 3, but any movement of water either through it or over it rapidly flattens such slope to about 1 on 20. For this reason the coffer-dam was kept 150 ft. away from the walls.

Owing to the distance of the lock from the shore and the necessary contraction of the river, it was thought inadvisable to include any of the navigable pass in the first coffer-dam, which was built therefore to inclose only the lock with arms extending to the bank. The area inclosed is about 20 acres. It is feared that this reduction of the cross-section of the stream will cause considerable erosion, and it may happen that the bed of the river will be so greatly changed as to make it necessary to raise the bed before it will be possible to construct the dam as planned.

The type of coffer (Figs. 1-2) is that known as the Ohio River box type, built 20 ft. above low water and 20 ft. thick for the greater part of its length; it consists of two rows of sheet piles 20 ft. apart, tied together by steel rods varying in diameter from ¾ in. at the top to 1¼ in. at the bottom, held apart by separators and held together by wales on the outside 6x6 in. at the top, varying to 10x10 in. at the bottom. The space between the rows of sheeting was filled with sand removed from within the coffer by a 10-in. suction dredge, the material being excavated from the lock site. The sides of the coffer were carried into the bank, the top being of uniform elevation 20 ft. above low water. To increase the stability of the coffer and decrease seepage a line of 7x12 in. triple-lap sheet piles, 20 ft. long, was driven outside of and around the coffer and bolted to it.

No special difficulty occurred during the construction of the coffer and seepage through the coffer was easily controlled by three 15-in. pumps placed on a pump boat resting on piles near the front of and discharging over the coffer. Some difficulty was met in the extension of the upper arm, owing to the fact that the river rose at a critical period and the pile driving and placing of skeleton of the coffer was carried on in water as deep as 17 ft. As this coffer-dam extends some 700 ft. from the bank at this stage there was, of course, a very serious current around the end, and extraordinary means had to be taken to protect the end of the coffer. Round piles with brush between them weighted

*Portion of paper in "Professional Memoirs, Corps of Engineers, U. S. A., and Engineer Department at Large," March-April, 1913.

†Major, Corps of Engineers, U. S. A., 425 Customs House, Louisville, Ky.

down by sandbags and rock were used, and after the corner was turned a pile of riprap was placed to protect it permanently against current and ice. The banking along the front of the coffer was protected by several masses of rock (Fig. 1) forming short spur dikes to prevent a racing current alongside the dike and the whole length of banking was covered with gravel. (Fig. 2.) This gravel was fine, the largest particles being not more than ½-¾ in. in diameter, and some of the material was practically nothing but coarse sand. In my opinion, this gravel is much too fine for the purpose intended and the contractor was so notified. He feels, however, confident that it will serve its purpose, and it will be very interesting to see whether his belief is justified.

The greatest trouble met in the unwatering of the coffer was in protecting the banking against the inside of the coffer from undermining by seepage and drainage water. Wherever there was flowing water the sand was eroded and the banking gradually sloped until it was almost flat. To prevent this, sandbags were used freely, and practically the whole caving surface was covered with the same kind of gravel as that used on the outside. For this protection this gravel was very suitable, and as soon as the sand was covered by a thin layer further erosion did not take place, and the banks remained with a slope of about 2 on 3.

It is believed that the Wakefield sheet piling driven around the coffer were not used to the best advantage. These piles should have been driven deeper, so as not to overlap the coffer sheeting over 5 ft., instead of about 13 ft. as actually driven, and should have been driven close to the coffer. The driving of a great part of the Wakefield piles occurred at medium stages of the river (10 to 17 ft.) with the result that the driving was poorly done and this sheeting is not as tight as it should have been.

The use of a pump boat with all of the pumps concentrated, the boat resting on piles as the water lowers, has been excellent and it is believed is very economical and much preferable to other methods commonly used. When the coffer is flooded the boats are simply disconnected from the discharge pipes, their suctions raised, and they are floated out of the coffer through the passway. This furnishes a very simple and economical manner of removing and placing the pumping apparatus.

This being the first coffer to be placed on sand foundations in the Ohio River, the contractors have taken very great care to use the best material and to make everything as secure as posible. It is possible that in future coffer-dams some of the measures adopted in this case may be found to be unnecessary and the cost of the coffer-dam material reduced.

CONSTRUCTION

The following is an extract of a report of the Government inspector in charge of the work, Junior Engineer Edward H. West, in which the work is described in fuller detail:

The coffer, both inside and out, is heavily banked with sand. A typical cross-section is shown on Fig. 2. Plans were closely followed in construction, the only exceptions being as follows: For a distance of 670 ft. from the land end of the upstream wing and 520 ft. from the land end of the downstream wing, tie-rods were spaced 8 ft. on centers instead of 6 ft. on centers; in some portions of the coffer, instead of 2x12-in. deck joists spaced 24 in. on centers, 2x10-in. joists were used, spaced 16½ in. on centers, and in a short portion of the river arm 2x10-in. joists 18 in. on centers were used. The sheet piles were driven from a floating pile driver, and at times the river was too high to permit the piles to be driven to the proper depth; consequently, such piles do not have quite the penetration intended, the maximum difference between actual and intended penetration being about 3 ft.; at the upstream outer corner the length of a number of sheet piles was increased to 32 ft. for additional safety at the point of supposed greatest weakness; at this corner about fifty round piles were driven as shown on Fig. 1, the area inclosed within them was filled with brush weighted with sandbags. Afterward the entire corner was protected with derrick stone piled as high as the top of the coffer. The lower outer corner was also protected by derrick stone and several stone dikes were built along the river side.

On June 20, 1912, the line of sheet piles was commenced, beginning at a point 250 ft. from the land end of the upper wing. These sheet piles were driven rather carelessly, making alignment poor, and leaving the joints not very tight. After the driving of sheet piles had been begun, trenches about 2 ft. deep and 20 ft. apart were dug parallel to the sheet piles. In these a skeleton was erected consisting of wales and those pieces of sheeting through which the tie-rods passed, the sheeting being driven about 2 ft. into the sand. All wales were scarfed for 2 ft. at both ends and holes bored for tie-rods through the center of the scarf. Where the spacing of tie-rods was 8 ft., 18-ft. timbers were used for wales and where the spacing was 6 ft., 20-ft. wales were used, thus allowing a lap of 2 ft. at each end. At each tie-rod a temporary separator perpendicular to the wales and 20 ft. long was placed and the nuts on the rod tightened. The remainder of the sheeting was then driven and after the proper cut-off elevation had been marked the ribbing strips were spiked on and the sheeting cut off to grade. Cracks between adjacent pieces of sheeting were closed by 1x3-in. battens nailed on the inside. When the coffer had been extended into water so deep as to prevent further work from land the skeleton was bolted together on a small barge, one section at a time, and as each section was completed it was lifted by a derrick boat until the barge could be moved forward, when it was lowered into the water (Fig. 3). Sheeting was then driven by men standing on the wales.

Throughout the construction two gangs of carpenters worked; at times each gang extended both skeletons and sheeting, but better progress was made when one gang worked on skeleton only and the other followed up with sheeting. Each gang contained at different times from 10 to 20 men; it was found that not more than 20 men could work together to advantage. In general, it may be said that the rate of progress depended upon the rapidity with which the

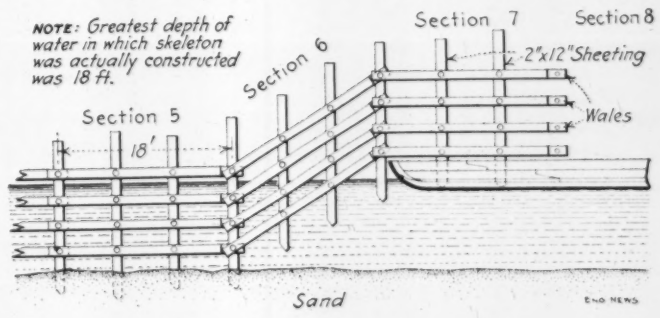


FIG. 3. METHOD OF CONSTRUCTING SKELETON OF COFFER-DAM

skeleton was advanced, no difficulty being experienced in keeping close up with the other work. As a matter of fact, sheeting was frequently delayed in order that the skeleton might be extended. During the season the skeleton was actually extended on about 71 days an average of 38 ft. per day; this value corresponds to two wale lengths, either 36 or 40 ft., depending on the length of wales being used; it was noted in the field that two wale lengths constituted an average day's work. Sheeting was actually driven on 53 days, an average of 52 ft. per day (double row) from a minimum of 10 ft. to a maximum of 103 ft., but on a great many days on which sheeting was driven much other work was done by the same gang and the above values are not reliable for progress estimates. It is believed that one gang can extend a double row of sheeting 100 ft. per day. The extension of skeleton may be assumed to be work accomplished by a single shift since night on this portion of the coffer is negligible; sheeting, however, was driven quite satisfactorily at night.

After the sheeting had been cut off to proper elevation, the deck joists were laid and spiked to the ribbing strips. This having been done, the discharge pipe of the 10-in. suction dredge was moved into position and the sheeted portion of the coffer filled with sand taken, if possible, from the "pay excavation" for the lock walls. Bulkheads across the coffer were built at convenient intervals as the construction advanced. As the coffer filled, the separators were removed and afterward used again. At first, a long trough built on top of the deck joists of rough lumber, on a grade of 1%, was used for distributing the sand, but it proved to be very inefficient and was discarded; subsequently the desired distribution was accomplished by moving the end of the discharge pipe. Short time tests of the suction dredge showed that it could place 100 cu. yd. of fill per hour, through 300 ft. of discharge pipe, maximum lift 20 ft. It handled a total of about 100,000 cu.yd. of material. The coffer contains only about 40,500 cu.yd.; the remainder was used for banking. Of the total excavation made, about 50% was within the specified limits of "pay excavation."

As shown on Fig. 1, a flooding sluice was built in the lower wing and a passway for removing boats, etc., was also left in the lower wing. Discharge sluices and coal tracks were constructed in the river side near the crest line of the dam. A layer of fine gravel was spread over the whole river side of the coffer-banking to prevent scour as much as possible. It is believed that the one flooding sluice will be all that is necesary, unless very extraordinary conditions

arise; in flooding the coffer when the river is near its top and too great a volume of water entering would endanger the permanent work, it is intended to place blocks behind alternate needles, as is often done in regulating pools above needle dams. In the event that this scheme should fail to pass a sufficient quantity of water to fill the coffer before it is topped by a rise, it is intended to use the passway as an emergency opening after constructing a temporary sluiceway.

The coffer-dam was closed Nov. 12, 1912. Inside were left both pump boats; the old derrick boat for use as a clam-shell dredge; and both pile drivers. A temporary sluiceway was constructed, discharging through the passway, and a coal track was built to supply fuel to the pump boat, which was temporarily located over the hole excavated for the lower gate track and recess. Gages had been set inside and outside the coffer and an inspector was kept on the pump boat continuously during the first pumping. The slope of the discharge water was measured in the sluiceway by a series of small gages set before pumping commenced, and the actual discharge while the pumps were making 350 r.p.m., was computed by Kutter's formula, using a coefficient of rugosity of 0.009, and found to be 24,000 gal. per min. for three pumps. An attempt was made to obtain more or less accurate estimates of the seepage through the coffer-dam at different heads. Since the pumpboat was floating, the vertical distance from water surface to center line of discharge pipes did not vary and the discharge was assumed as constant at 480,000 gal. per pump-hour as measured. The inside gage was read as closely as was possible (to hundredths of a foot) and recorded hourly and a careful record kept of the actual number of pump-hours run. The outside gage was read at 8 a.m., 12 m., and 4 p.m., and the river stage at other hours could readily be estimated. From the readings of these two gages the head on the coffer at any time could be computed. A careful survey had been made of the interior of the coffer by soundings on Oct. 31; from the data obtained by this survey a contour map was plotted on a scale of 1 in. = 40 ft., contour interval 1 foot, and areas were measured by planimeter at each foot of elevation through the probable range of water surface during pumping. The area of water surface at each hour was obtained by interpolation and the amount by which the water content of the coffer was reduced was computed by average end areas; the seepage during each hour was taken as the difference between the amount of water handled by the pumps and the amount by which the coffer content was reduced.

While conditions were such that an absolutely accurate estimate of seepage is impossible, the values given* are believed to be close enough for all practical purposes. It would seem that the seepage should vary as the square root of the head, following the well known laws for flow through pipes and orifices, the passage of the water through sand amounting to flow through an infinite number of minute pipes, but the values actually obtained as outlined above indicate a straight line variation, that is, directly as the head.

After the piles for the pump boat foundations had been driven and capped the coffer was allowed to fill, the boats were floated into position and pumped down, allowing them to settle on their foundations. Pumping was continued until the water surface inside reached an elevation of 310.7, when the coffer was accepted as satisfactory; it was then allowed to fill up to 316, and driving of round piles for river wall foundation was begun from floating drivers.

Seepage was apparently uniform around the entire coffer perimeter, since a single large leak would have resulted in great damage and the wrecking of a portion of the coffer-dam. Naturally, this seepage water collected into a relatively small number of rather large streams, moving toward the pumps, each of which caried a large quantity of sand, which was deposited in the still water where the pile drivers were floating. Taking care of the seepage was a simple matter, but serious difficulty was encountered in preventing the excavation from filling with this sand. The clam-shell dredge proved to be an inefficient and costly method of solving the problem.

On several occasions pile driving was suspended until sand thus washed in could be removed. It was thought that by building dams of sandbags across those streams the movement of sand could be stopped. This was done and proved to be very advantageous, but when water began to flow over the dams sand continued to move into the excavation, though in diminished quantities. A further diminution in this sand movement was effected by spreading a 6-in. layer of gravel over the greater part of the river side of the interior banking. In spite of all efforts, however, large quantities of sand continued to move into the "hole" and at the time work was suspended for the winter the problem of driving piles without constant excavating was still unsolved.

*A fair approximation to a straight line, varying from 18,000 gal. per min. at 20-ft. head to 4500 gal. per min. at 5-ft. head.—Ed. "Eng. News."

Rates of Rainfall for Storm-Sewer Calculations

By J. A. Cushman*

Recently in making estimates for a sewer system the writer had occasion to use formulas for storm-water flow. The widely differing results obtained from different formulas led to further study of rates of rainfall. A tabulation was made showing for a considerable period of years all the storms of a greater rate than 0.1 in. per hr.

Since 1897, observations of rainfall have been made at four stations on the watershed of the Wachusett Reservoir (Metropolitan Water-Works of Massachusetts). The accompanying table gives the results at one station—Jefferson in the town of Holden, Mass. This point is in Worcester County, near the center of the state of Massachusetts, and at an elevation of 820 ft. above sea level, the measurements were made by weighing the amount of rainfall by means of properly graduated scales, and the results are probably characteristic and true for the central and south part of New England.

It is shown in the table that a rate of over 1 in. of rain falling in an hour is an exception, this rate occurring approximately three times in five years, and that a storm of over 1¾ in. per hr. is a rarity—only one occurring in 16 years. The table shows, moreover, that only once a year can a rate of over ½ in. per hr. be expected. Yet engineers are using McMath's formula which, although it takes the rate of rainfall into account, is

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RATES OF RAINFALL IN THE TOWN OF HOLDEN, MASS., 1897 TO 1912

Rate*	0.1 to 0.2			0.2 to 0.3			0.3 to 0.4		0.4 to 0.5	0.5 to 0.6	0.6 to 0.7	0.7 to 0.8	0.8 to 0.9	1 to 1¼	1¼ to 1¾	Over 2
Year	Sh.	Rn.	Sn.	Sh.	Rn.	Sn.	Sh.	Rn.	Sh.	Sh.	Sh.	Sh.	Sh.	Sh.	Sh.	Sh.
1897	3	5	1	2	2	0	1			1		1		1		
1898	7	6		4	1		2	1		1		1			1	
1899	3	1			1				1	1	1			1	1	
1900	2	4		4	1		1				1		1			
1901	1	5			2		1		1							1
1902	3	4	1		1								1			
1903	3	2						1	1							
1904	4	2			1			1		2		1		1		
1905	2	1					1		4			1			1	
1906	5	6	1	3	3	0	1		2					1		
1907	2	6	0	1			2	1	1		1	1				
1908	6	7		3	1		2		1	1				1		
1909	3	8		3	2		1	1	2							
1910	5		3	7			2		1		2					
1911	8	3	1	1	1		1		1	1						
1912	4	8		3	1			1								
Totals, 16 yr.	61	68	7	31	17		15	6	13	7	5	5	2	5	3	1
Occurrence	8-9 in 1 year			3 in 1 yr.			4 in 3 yr.		1 each yr.	1 in 2½ yr.	1 in 3½ yr.	1 in 3½ yr.	1 in 8 yr.	1 in 3½ yr.	1 in 5½ yr.	1 in 16 yr.
Av. duration	6½ hr.			4¼ hr.			2¼ hr.		1¼ hr.	1 hr.	1 hr.	35 min.	1¼ hr.	55 min.	1 hr.	20 min.

* Inches of precipitation per hour. Sh. = Shower less than 3 hours duration. Rn. = Rain more than 3 hours duration. Sn. = Snow.

based on a rate of 2.75 in. per hr., and Fanning's, which apparently assumes a rate of 2.75 in. as a maximum and leaves no opportunity to reduce or correct this rate.

The whole question of runoff is extremely uncertain and depends not alone on the rate of rainfall, but on the porosity of the soil, the slope of the area under consideration, the characteristics of vegetation (cultivated, pasture, forested, etc.), the number of buildings, and possibly other factors. Without doubt, it is impracticable to attempt to devise a working formula for runoff. In fact the writer is inclined to think that, for the sake at least of calculations of sizes of sewer pipe required in city and town systems, it would be just as accurate and much simpler to say that the amount of storm water in cubic feet per second will be the product of the rate of rainfall (reduced to feet per second) by the area in square feet. It is at least on the safe side, and that is more than can be said of some of the existing formulas. Of course this result assumes that no water seeps into the ground and that it all gets to the sewer at the same rate that it falls. Assumptions (depending on local conditions) based on the various factors above mentioned may be made, and this large quantity may be reduced as much or as little as the judgment of the engineer may dictate. The amount of the appropriation may also take a hand in the process of reducing the amount of storm water to be taken care of in the sewers.

The total *quantity* of storm water brings in the factor of *duration* of heavy showers. The table shows that storms of excessive rates are showers of less than three hours' duration, in fact the heaviest rate, which was 2.40 in. per hr., lasted only 20 minutes, and with two exceptions all of the storms of more than 0.4 in. per hr. lasted less than two hours. Almost all these storms occurred in the summer time when the ground was most receptive. It is interesting to note that there were no snowstorms of greater rate than 0.2 in. per hr., and only seven in 16 years greater than 0.1 in. per hr.

Based on a study of these results, it seemed to the writer absurd to assume as a maximum rate of rainfall, in this part of the country, 2.75 in. per hr., and uneconomical to assume a rate of more than 0.5 in. per hr.

Growth of a Commercial Research Laboratory

The development of the physical and chemical research laboratory of the General Electric Co. in the twelve odd years of its existence shows many features of general interest. In 1901, Prof. W. R. Whitney, of the Massachusetts Institute of Technology, was engaged to organize a department of chemical and physical research. By the middle of that year the force employed had reached the number of five and this soon was increased to a dozen, but it was three years before Prof. Whitney left the Institute and devoted his entire time to this project.

The first laboratory was in one small room in an old building, but at the end of the first year it was necessary to remove to larger quarters. About the time Prof. Whitney took complete personal oversight of the work, the number of assistants had reached 35 and it was necessary to move again. Then the present quarters were secured, consisting of some 40 rooms, each about 20x20 ft. These all have good natural and artificial illumination and are piped for water, illuminating gas and hydrogen, with nitrogen, oxygen, steam, suction and compressed air in a few rooms. A complete system of wiring makes electrical energy available in each room with potentials up to 6600 volts, currents up to 200 amp. and power up to 150 kw. For furnishing this supply one room is equipped with some 15 motor-generator sets of up to 200 hp. variously arranged to secure the necessary range of voltages and frequencies. Of course, a machine shop and supply room are adjuncts, and there is a special library (distinct from the main technical library of the company in another building).

The department will move again shortly, for the company is building a seven-story brick building at a cost of about $300,000, exclusively for housing this department and the standardization laboratory. One of the features of this building will be an assembly room for the accommodation of general staff discussions which are held for an hour and a half on each Saturday morning.

Among the hundreds of investigations which have been brought to successful conclusions, some have stood out because of magnitude and importance of commercial results. Among these there should be mentioned first perhaps, the production of ductile tungsten for incandescent-lamp filaments. After that in close order come the development of the metallized-carbon lamp filament, the mercury-arc rectifier, the magnetic-arc lamp, silicon steel for transformers cores, special-alloy resistance wires, new electric furnaces and innumerable furnace products, the improvement of insulating materials and metallurgical operations, etc.

It is believed by the enthusiastic workers in this laboratory that the conditions here for successful investigation are ideal; each man is one of a group marked by its training and enthusiasm for chemical and physical study. The resources of the company back of the laboratory are varied and great, and it is assumed that, if the probable results of an investigation are sufficient to warrant its pursuit, then time and money are little considered. Some $200,000 is now spent annually on the laboratory.

One factor which has contributed much to the satisfaction with which men have pursued important investigations is the willingness of the company to publish his results at the proper time. This is done through papers before various technical societies by the principal investigators themselves. Instances of this are seen in the announcements which have been made from time to time of the use of boron for producing homogeneous copper castings, the production of ductile tungsten, the derivation of laws for conduction and convection transfer of heat from solids to fluids.

A Saving of $40,000 a Year in Water Filtration Cost at Pittsburgh, Penn., in 1912 is noted in the annual report of Charles A. Finley, Superintendent of the Water Bureau. This saving is attributed to improved methods of operation, particularly as regards sand handling. The new methods were suggested by George A. Johnson, of New York City, who was engaged in 1910 to report on certain features of construction and operation of the plant. Mr. Finley says:

> The principal changes in operating conditions within the filters were the introduction of the process of "raking" the filters between "scrapings," thereby securing additional yields from the filters at less expense than by continuous scraping, and a change in the process of restoring sand from restoring by machine to restoring from open hose lines under water.

An account of constructional changes in the Pittsburgh water purification plant, written by Mr. Johnson, appeared in our issue of Oct. 3, 1912, p. 610.

Two New State Public-Utility Laws

The States of Indiana and Missouri have recently adopted new public-utility laws which become effective soon.

INDIANA—The Indiana public-utility law, which becomes effective on May 1, abolishes the old railroad commission and confers its rights, powers and duties on a new Public Service Commission. This will consist of five members, not more than three of whom are to be members of one political party. Members are appointed by the governor for a four-year term and at a salary of $6000; the commission elects its own chairman. The governor also appoints a general counsel for four years at a salary of $6000. A secretary is provided at $3600 and a clerk at $3000. The employment of attorneys, engineers, experts, examiners, accountants, etc., is authorized.

The commission is given broad powers over the rates and services of public-service companies and authority over the issue of stocks and all evidences of indebtedness. It can ascertain and fix standards for testing the quality and adequacy of service and for the examination and testing of all related appliances. It can inquire into the management of business of all public utilities and obtain all necessary information, having the right to inspect books, accounts, papers, records, etc., and to examine under oath any officers, agents or employees. It is charged with the determination of proper and adequate rates of depreciation for the several classes of property of each public utility. It is required to keep itself informed of all new construction, extensions and additions, and to fix the form and manner of keeping construction accounts so as to distinguish between operating expenses and construction.

The statute defines a "public utility" as including municipally owned, operated or controlled heat, light, water, power, railway, telegraph or telephone companies; and "service" is construed to include not only accommodation for customers but also any product or commodities furnished.

The statute imposes many injunctions on public-utility concerns. They are required to keep and render uniform accounts such as may be prescribed, to have an office in some town or city of the state where some of its property is located, and there to keep its books and records. Adequate depreciation allowances must be carried and based upon the determination of rates of depreciation by the commission. These charges may be carried in a fund expended in new construction or invested in certain securities. Each company must forward rate schedules to the commission and keep copies open for public inspection. No stocks or evidences of indebtedness may be issued except for money or labor or property actually received and equal to not less than 75% of the value of such paper. Bonded indebtedness of any utility must bear a reasonable proportion to the total issue of capital stock, considering the nature of the business, credit, future prospects and earnings. Money received from the sale of securities must be applied to specified purposes.

The commission is enjoined from authorizing the capitalization of franchises, or rights to own or operate a franchise, in excess of the amount actually paid to the community as a consideration. On merging two corporations, the combined capitalization must not exceed the sum of the capital stock of the two constituents, except for new cash actually paid out. The law expressly states that the state does not indorse or guarantee any issue of securities. No utility concern can transfer or lease its franchise or system without the consent of the commission, and no concern can directly or indirectly acquire stocks or bonds of another corporation engaged in such business unless authorized to do so by the commission. Only upon the consent of three-fourths of the capital stock outstanding can two systems be jointly operated.

The law prohibits competition in any given territory unless the commission shall declare at the public hearing that public convenience and interest require it.

The law provides for issuing indeterminate permits which continue in force until a municipality exercises its inherent option to purchase the property, or until the permit shall be terminated otherwise by law. By filing a declaration of surrender prior to July 1, 1915, any public utility can exchange its existing license or franchise for an indeterminate permit. To secure a permit, a new utility must be a corporation organized under the laws of Indiana or be owned by a citizen of the state. The acceptance of such a permit is deemed to be a consent, without recourse to law or courts, to the future purchase of its property by the municipality in which the major part is situated and at a valuation to be fixed by the commission.

Free service, passes, special privileges and rebates are forbidden. All accidents attended with loss of human life must be immediately reported to the commission which may investigate and inquire into neglect or violation of any state law or ordinance.

MISSOURI—The Missouri bill, which was signed on Mar. 18, abolished the old railroad Commission, repealed the statute by which the municipal assemblies of various cities were impowered to create local utility commissions, and established a new state commission with broad powers and duties.

The new body consists of five members at a salary of $5500; $4500 is provided for an attorney; $3600 for a chief clerk; $1800 each for other clerks and $1200 each for stenographers. Examiners, accountants, agents, experts, engineers, inspectors, etc., may be appointed by the commission.

The commission is given control of the issue of all public-utility stocks and bonds and the regulation of rates and service. Depreciation funds of all utility concerns are required by this statute in accordance with the determinations of the commission, which also has the power to fix physical value for purposes of taxation and rate making. It has exclusive jurisdiction in the abolition of railway grade crossings and the distribution of the cost thereof. New railroad or street-railroad construction must be in accordance with a permit obtained from the commission. The commission may require three brakemen on freight trains if it deems necessary and may compel the general installation of electric head lights. It may demand additional switching facilities, improvements of track or rolling stock, the construction of stations, uniform accounting, and adherence to a fixed railroad schedule; judgment of adequacy of service and the proper handling of rolling stock is specifically laid upon the commission. The power to investigate interstate rates is also given and the right to apply to the Interstate Commerce Commission for relief when it desires.

Conditions of Small Water Purification Plants in Illinois*

By Ralph Hilscher†

In Illinois there are about a dozen water purification plants with rated capacities of about 2,000,000 gal. per day, or less, which involve the use of coagulants, settling basins and filters. Of these, with possibly two or three exceptions, it can be said that none produce an effluent that attains at all times the standard of purity that any municipality should demand for its public water-supply. Some of these plants yield an effluent during the major part of the time, which is of quite satisfactory quality, but fall far short of successful operation during periods of excessive turbidity and color in the raw water. Others produce an effluent at no time that is of good appearance and satisfactory from a hygienic standpoint.

The poor results realized are due largely to certain faults in design and operation, which are more or less common to these small installations. Many of the plants are of obsolete design, and in practically all the plants too great economy was attempted in building and certain essential features were omitted. The operation has usually been deficient due to lack of experience and expert advice in such matters. Certain faults largely responsible for the short-comings of these plants will be discussed.

CHEMICAL FEED

In a small plant the matter of economy in the use of chemicals is not of great importance, for the amount that can be saved by the greatest economy along this line is very small in comparison with other costs. What is most desirable is that the chemicals be added at as uniform rates as practicable, consistent with simplicity in mode of application. In many plants, however, simplicity seems to have been the foremost consideration, and greatly at the expense of uniformity in application. Undue economy also seems to have been attempted in some cases. Probably the simplest method of chemical feed, and the method used in a number of these small plants, consists of preparing the chemical solution and applying it in a single continuous operation. This is accomplished by placing the dry chemical in a small tank, through which there is a continuous flow of water, and allowing the overflow (carrying chemical in solution) to pass to the water receiving treatment.

The uniformity of dose administered by this method depends mainly upon the frequency with which the supply of undissolved chemical is replenished, and may also be materially affected by temperature. If the quantity of undissolved chemical is approximately the same at all times the strength of solution applied will be fairly constant, but very often operators cannot be depended upon to give this matter proper attention. In one instance a solution of iron sulphate was found to weaken about 15% in one hour, and at this plant it was the practice to recharge the tank only as often as once in about six hours.

The solubilities of chemicals are affected more or less by the temperature of the solvent. For instance, the solubility of iron sulphate in water at 45° F. is only about 66% of what it is at 70°. Alum, on the other hand, is but little affected in solubility by temperature, varying about 7% between 45° and 70° F.

The most reliable and simple means of feeding chemicals is probably by the use of a constant-head orifice box fed through a float valve from a tank containing a supply solution having a constant strength. By this means the uniformity of dose need be subject to no interruptions so long as the rate of pumping is constant, as is ordinarily the case in a small plant.

SEDIMENTATION

The period of sedimentation that should be given a coagulated water (previous to filtration) to afford the maximum efficiency for the entire plant depends somewhat upon local conditions. But as a general rule, it would seem that a detention period of at least four hours would be desirable with such waters as are found in most Illinois streams. In 12 small gravity filter plants in Illinois the theoretical settling periods range from zero to about 8.8 hr., and the average is in the neighborhood of 3.5 hr. In addition, there are a number of pressure filter plants where no sedimentation is provided.

These settling periods, however, figured as the total volume contained between the walls of the basins, are frequently not realized fully on account of improper baffling, which results in considerable dead space. In two instances there are provided circular basins with radial baffles, and the course taken by the water is around the inner and outer ends of these baffles, successively through the various compartments. With such an arrangement the rates of flow in different parts of the basin must necessarily be widely different, for in each of the compartments there is a large space in one corner that is of almost no service on account of its containing practically dead water. In a number of other instances there are basins of rectangular shape across which the flow is in a diagonal direction. In such a basin also there is dead water in two corners remote from the diagonal line of flow.

To obtain the fullest benefit from the available settling capacity a basin should have such inlet and outlet facilities as will effect a uniform rate of flow throughout the whole cross-section. This may ordinarily be accomplished easily by admitting the water to the basin through numerous small holes in a vertical wall at the inlet end, and by drawing it off over a weir extending across the outlet end.

FILTRATION

A variety of faults may be found with the filters themselves in various plants, especially in the older installations. The most objectionable features ordinarily lie in the method of control, in the facilities for washing the filters, and in the character of the filter medium. Other features of importance, such as arrangement of pipes and valves and convenience for operation, are also frequently open to criticism. A wide variation in the character of filter sands exists in Illinois, the effective sizes ranging from 0.28 to 0.85 mm., and the uniformity coefficients from 1.15 to 2.10. These sands are more often too coarse than too fine, a characteristic which makes filtration more economical but less effective.

In a number of plants proper control of the rate of filtration is not possible on account of the absence of automatic controllers on the effluent pipes. Without these the load of the filtration is certain to become unequally distributed between the various units. In two of the smallest of these plants, where but single filter units are installed, some pretense is made at regulating the rate by occasionally adjusting a gate valve on the effluent pipe, but the effectiveness of such control depends wholly upon the skill and watchfulness of the operator, which is undesirable. In washing filters, the ultimate consideration is economy. The main object should be to filter a given amount of water using a minimum amount of wash water, and of air if that be used for agitating the sand during washing.

The majority of plants are not provided with loss-of-head gages, so the operators cannot know when the proper time to wash, consistent with best economy, arrives. It is frequently the practice to wash once every 24 hr., regardless of the character of the water treated and of the real filter needs. In one plant the filters are so poorly equipped for washing that the filter medium much of the time is of a muddy, clayey appearance, while, as a matter of fact, when clean this sand is of excellent character for filter needs. The filter runs between washings here are at times only two hours. In another plant the amount of air used in agitating has been so great that the violence of washing has caused about one-third of the original sand to be lifted into the waste gutters and carried away.

OPERATION

Unfortunately the small city or water company cannot afford (or is not willing) ordinarily to make the necessary expenditure to obtain expert filter operation. As a result the operation is usually left largely to the pumping station engineman, who is possibly a good mechanic and well equipped for his own line of work, but who, frequently, has never even seen any other filter plant than the one of which he has charge. Very few plants are equipped with laboratory facilities for testing the quality of filtered water. In the majority of cases the only test is that of appearance, and even in this the standards at some places are surprisingly low. In two or three instances the water has a milky appearance a large part of the time; but this is not objected to because it is somewhat of an improvement over the water delivered previous to the installation of filters.

In fact, the local authorities have not, as a rule, had a fair understanding of what a purification plant should be able to accomplish, and there is rarely anyone who has the time or the inclination to look beyond his own experience enough to really appreciate the fact that the best results under the circumstances are not being obtained.

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*Abstract of a paper read at the annual meeting of the Illinois Water Supply Association, at the University of Illinois, Mar. 11, 12, 1913.

†Assistant Engineer, State Water Survey, Urbana, Ill.

New Intake for the Capilano Water-Works, Vancouver, B. C.

By H. M. Burwell.*

In the year 1906, an intake to the new 36-in. water-supply main then constructed for Vancouver, B. C., was placed at a point known as the "Pool," about ¾ mile upstream from the original intake at the dam, which has since been abandoned. This pool (Figs. 1 and 2) is formed by a reef of granite rock extending out into the channel of Capilano Creek, from the east side, and has a depth in the center of about 15 ft. at low water.

The intake pipe and racks were placed in the pool (see Fig. 1) just behind this point of rock, clear of the current of Capilano Creek, which is a very rapid running mountain stream, with a fall of about 80 ft. to the mile.

The deflection of the current by the above-mentioned point of rock caused an eddy in the pool behind, which had heretofore always kept it deep and free from gravel or sediment, and for this reason it was thought at the time to be an ideal location for an intake.

Subsequent experience proved that the slight alteration of the natural conditions caused by placing this intake, changed the eddy to such an extent that large quantities of sediment were annually deposited in what was originally deep water in front of the intake, greatly reducing its value.

After having observed the operation and effect of this intake for four years, it was decided to construct a new intake in the center of the point of rock referred to, so that the water entering into it would flow in a direction at right angles to the current of the Creek.

In a mountain stream of this nature, which, at freshet times, occurring once or twice a year (usually in the month of November), carries down great quantities of boulders, gravel and sediment, the advantage of this arrangement is obvious. The velocity of the creek current being very much greater than the velocity of the water entering into the intake, carries the most of the sediment past the intake which would otherwise enter into or pile up in front of it.

The new intake (Figs. 2 and 3) has a width of 10 ft. and height of 18 ft., the latter fixed by the highest known flood level during the last 25 years. The intake has reinforced-concrete side-walls and a concrete bottom, the entrance being provided with head-racks of oak strips set in angle-iron frames.

There are four racks, each measuring 5x9 ft., placed in guides, formed with an I-beam in the center, and channels set in the concrete walls. These racks extend from the bottom to the top of the intake and can be raked at any stage of the water and removed when desired.

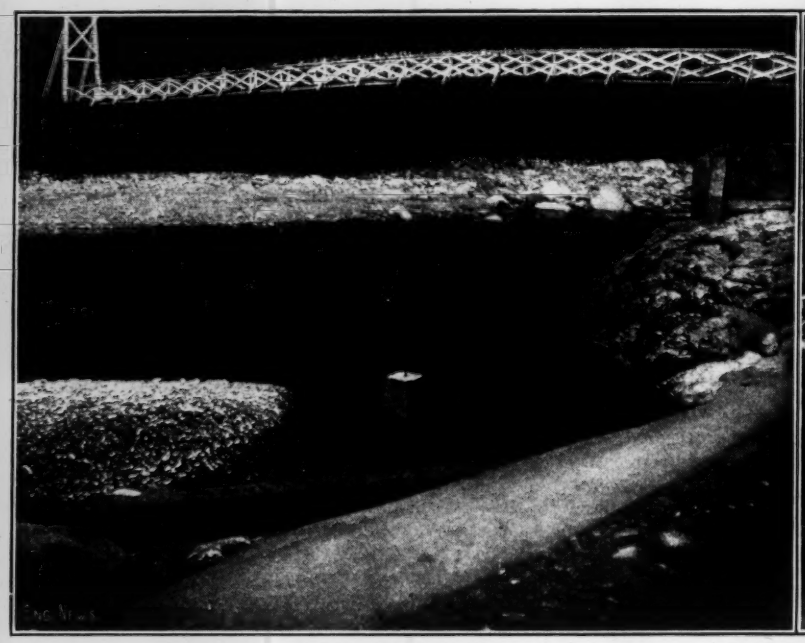


Fig. 1. General View of Both Intake Sites

Fig. 2. Front View of New Intake, Showing Head Racks

Figs. 1 and 2. Old and New Intakes at Pool on Capilano Creek, Water-Works of Vancouver, B. C.
(The position of the old intake is indicated by the concrete pedestal. The eddy in the pool shows clearly in each view).

The upper section of the intake conduit, for a length of about 75 ft., was excavated through granite rock. In plan it has a sharp curve at a point about 40 ft. from the intake and below this point its width reduced to 7 ft.

The head gate is placed at a point 175 ft. from the intake and below this point the side-walls of the conduit are reduced to 10 ft. in height by three steps.

The conduit is an open concrete flume, and has a total length of 570 ft. from the intake down to the sediment tanks.

It is constructed throughout with side-walls 12 in. in thickness reinforced with ¾-in. round iron. Beams extend from one wall to the other to withstand the pressure of the earth banks.

The bottom of the flume has a thickness of about 12 in. and below the head gate it is also reinforced to withstand the upward pressure which is put against it during the high-water stages of the creek, owing to the porous nature of the ground.

The head gate is built of channel irons and has a

*Engineer-in-Charge Water-works Extensions, Vancouver, B. C.

width of 7 ft. and a height of 5 ft. 10 in. It is placed in channel guides set in the concrete walls and is operated by a long stem and spur-gear, which is fastened to the channel frame set on top of the walls. The gate opening at the bottom of the flume is 5 ft. in height and above this is a concrete bulkhead reinforced with steel rails.

There are two gates at the lower end of the flume

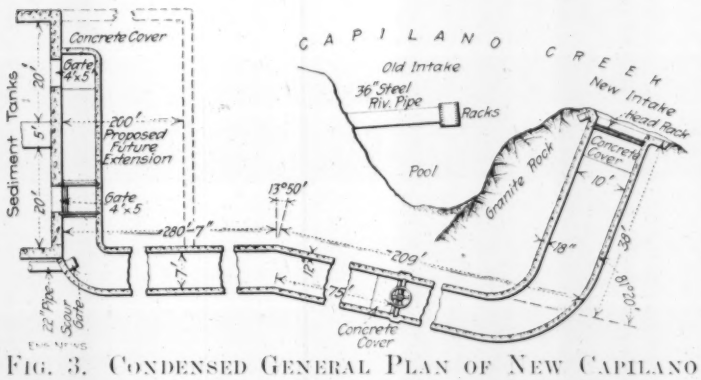


FIG. 3. CONDENSED GENERAL PLAN OF NEW CAPILANO INTAKE, FOR WATER-WORKS OF VANCOUVER, B. C.

which admit water into each of the sediment tanks. These gates are set in holes 4x5 ft., cut in the concrete wall of the tanks.

The new intake was put in operation in the month of August, 1912, and in the following November was subjected to a very severe test by an extremely heavy freshet

FIG. 4. LOOKING DOWN CAPILANO INTAKE TOWARD HEAD GATE AND SEDIMENTATION HOUSE

in the creek. It was observed, after the water receded, that not more than about one-quarter of the usual sediment was deposited in the tanks, and in every other respect the new intake has proven to be much superior to the old one.

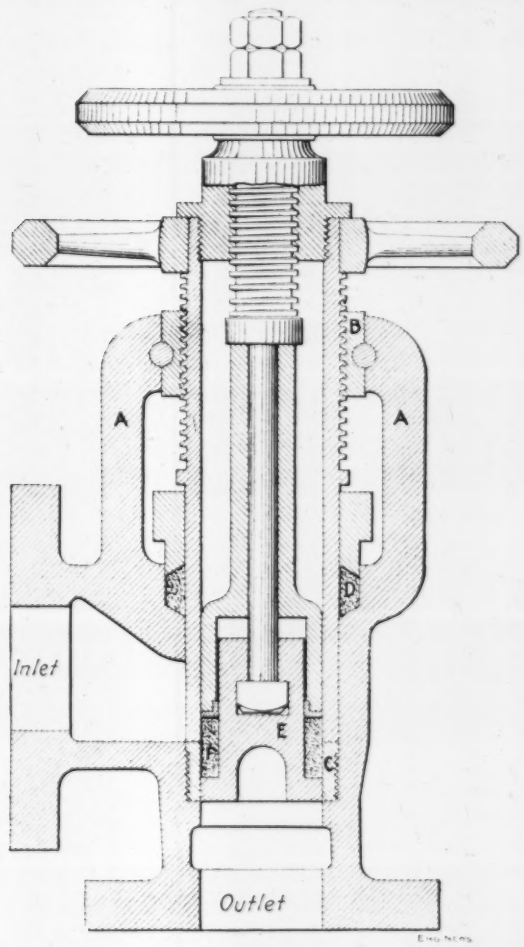
The intake was designed and its construction was supervised by the writer and the construction work was performed by the water-works superintendent of Vancouver, with day labor.

A Double Plunger Angle Blowoff Valve

The accompanying cut shows a novel form of blowoff valve, which is so designed that it does not depend for its tightness on a metal to metal joint. The body of the valve and the yoke A are cast in one piece. A bushing B is inserted in the yoke and keyed in place by two bolts. The valve seat C has finished top and inside surfaces and is screwed into place so that it can be removed when necessary. The sleeve valve has its lower annular face ground to fit the top of the valve seat and leakage upward along the sleeve is prevented by packing at D. The plunger valve E is ground to a sliding fit inside the valve seat and packing at F serves to prevent leakage around the valve stem and also leakage past the valve seat to the outlet.

The cut shows the valve closed. To open it the upper handwheel is first rotated its full limit, drawing the plunger valve up until its lower face is flush with the bottom of the sleeve valve. The valve is then opened by rotating the lower handwheel. In closing the process is reversed.

These valves are made by the Eynon-Evans Mfg. Co.,



A DOUBLE-PLUNGER ANGLE BLOWOFF VALVE

of Philadelphia, Penn., in sizes from 1½ to 3 in., inlet diameter. They are tested to withstand 600 lb. per sq.in., hydraulic pressure.

Hydraulic Dredging on New York Barge Canal

By Emile Low*

SYNOPSIS—The excavation required for enlarging the New York State Canals to form the 12-ft. Barge Canal across the state amounts to 110,000,000 cu.yd. A large amount of this material is being removed by hydraulic suction dredges, which have been specially designed for the work. The record of the performances of these dredges will be of interest to every contractor and engineer who deals with earth handling. Descriptions of some of the most recent types of 20-in. suction dredges are included, together with the approximate costs of operating them, and the contract prices for excavation in the Barge Canal construction.

The enlargement of the New York State Canals requires the excavation of over 110,000,000 cu.yd. of material. Much of this excavation is being done by hydraulic dredges, supplemented by dipper and ladder dredges. Because the route of the enlarged canals, in large measure follows the alluvial beds of the Hudson, Mohawk, Oneida, Oswego, Seneca and Clyde Rivers, the conditions are particularly favorable for the use of hydraulic suction dredges.

Work of the Dredges "Oneida" and "Ontario" on Contracts Nos. 4 and 5

The first work of this character was done on Contract No. 4, at the eastern end of Oneida Lake, and further west on Contract No. 5, along the reaches of the Seneca River and through the Montezuma marshes by the Empire Engineering Corporation, with two hydraulic dredges, built especially for the work, after designs by the former president of the company, Lindon W. Bates.

These dredges, the "Oneida" and the "Ontario," were built so as to pass the locks of the present Erie Canal, and are of the following dimensions: length 97 ft., beam 17.5 ft. and molded depth to deck, 10 ft., with a light draft of 5.5 ft. To insure stability during dredging operations, pontoons were attached, one on each side. The dredges went into operation late in the fall of 1906. A full description of the dredge "Oneida" was published in Engineering News, of Dec. 5, 1907.

Owing to a change of location in the part of the canal under Contract No. 5, west of Fox Ridge, the dredge "Ontario" was transferred to Contract No. 4, during the spring of 1908. While on work on Contract No. 5, the dredge excavated 901,601 cu.yd., mainly during the year 1907. During four months of this period its average output was about 5300 cu.yd. per day, although at certain times it accomplished over 16,000 cu.yd. in a single day. After June, 1908, until the completion of the contract (No. 4), both dredges were employed on this work. Although three hydraulic dredges, the "Oneida," "Ontario" and "Owego" were employed on Contract No. 4 during the year 1908, the output was only about 700,000 cu.yd., the main reason for the small yardage being that the cutters were unsuitable for the material encountered.

A new cutter and other machinery were installed in the dredge "Ontario" during the winter of 1908-'09. The remodeled dredge during April, 1909, excavated 141,147 cu.yd. of material, working in a 25-ft. cut, of which the lower 5 ft. consisted of hard clay containing many boulders. One of these entering the suction pipe, caused a delay, which materially reduced the month's output. It may be added that blasting was necessary to loosen this material. The best output of the "Ontario" was during the month of June, 1909, when 172,844 cu.yd. were excavated, which, however, included a small yardage done by the "Owego."

The original estimate of excavation on Contract No. 4 was 2,280,000 cu.yd., the contract price being 14c. per cu.yd. The final estimate was 2,844,909 cu.yd. As about 30 months were occupied in the dredging operations, the average monthly output was about 90,000 cu.yd. which appears small when there are records of nearly 20,000 cu.yd. for a day of 24 hours. With the exception noted above the material pumped was a very fine sand, so light and friable when dry that the wind would blow it about.

Contract No. 4 is one of the first six advertised and let, the date of letting being Apr. 18, 1905. The contract extends 4.83 miles east from Sylvan Beach at the eastern end of Oneida Lake, up the valleys of Fish and Wood creeks. It was finally completed in July, 1910. The contractor's bid was $726,815, and the final estimate was $720,073.

Work of the Dredges "Champlain" and "Fort Edward" on Contracts Nos. 15 and 25

The Atlantic, Gulf & Pacific Co. is contractor for Contracts Nos. 15 and 25, on the Champlain canal, extending from Dunhams Basin northward to Lake Champlain, at Whitehall, a distance of nearly 20 miles. The engineers' estimate of excavation on Contract No. 15 was 2,900,000 cu.yd. and on Contract No. 25, 4,763,000 cu. yd., a total of 7,663,000 cu.yd. Certain alterations on Contract No. 25 increased the amount of excavation about 800,000 cu.yd. The contract price on No. 15 is 28½c. and on No. 25, 23c. per cu.yd.

Two hydraulic dredges built especially for these contracts began excavating in 1907. The "Champlain" on Contract No. 15, and the "Fort Edward" on Contract No. 25. During the winter of 1907-1908 numerous repairs and improvements were made on them, resulting in largely increasing the output. The dredge "Fort Edward" excavated 216,425 cu.yd. during the month of May, 1908, while the work of the "Champlain" was 204,838 cu.yd. during the same period, although about three days were lost in delays of various kinds. The dredges worked three shifts of 8 hours each, on 6 days of the week. Contracts Nos. 15 and 25 are adjacent pieces of work, operated under one management.

The "Champlain" during September, 1908, excavated 231,473 cu.yd. and the "Fort Edward" 255,859 cu.yd.; the output of the latter dredge during October, 1908, was 261,149 cu.yd. while dredging south of the Smiths Basin highway. Up to this time these were the largest monthly performances of single dredges on the canal construction. The actual performances of these dredges were considerably larger by reason of extra excavation which the contractor did for his own convenience in prosecuting the work. These additions increase the out-

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put of the "Fort Edward" by about 40,000 cu.yd. and that of the "Champlain by 28,000 cu.yd. for the month of September, 1908. The whole record of excavation for this month, including both paid and unpaid work, reached a total of more than 622,000 cu.yd.

Following these large monthly outputs the work of the two dredges rapidly fell off, hovering around the 100,000-cu.yd. mark during the favorable summer months and was very much less during the unfavorable spring and fall months. However, in September, 1910, the output of the "Champlain" reached 318,193 cu.yd. and in October, 1910, it excavated 500,352 cu.yd. of material. Although a part of the excavation came from below grade, the paid material was 470,352 cu.yd., a quantity considerably above the record of any other single dredge on the canal up to this date. Reduced to actual working time, 565 hr. and 35 min., the average yardage per hour was 885 cu.yd., or over 21,000 cu.yd. per day of 24 hours.

What interests the engineer and the contractor is the average output and not sporadic instances. The work of the "Fort Edward" occupied about 17 months, during which time about 2,400,000 cu.yd. of material was excavated, or at the rate of 140,000 cu.yd. per month. Dividing the operations of the "Champlain" into two periods, we find for the first, an output of 2,000,000 cu.yd. during 13 months—150,000 cu.yd. per month, and for the second period, 1,400,000 cu.yd. in 18 months, a monthly rate of 80,000 cu.yd. For the whole period, 31 months, the average monthly rate was 120,000 cu.yd.

Work of the Dredge "Geyser" on Contract No. 12

Contract No. 12, originally held by the Stewart-Kerbaugh-Shanley Co., extends from Brewerton, at the western end of Oneida Lake to the Montezuma marshes at Fox Ridge, and follows generally the course of the Oneida and Seneca Rivers, with occasional cutoffs where long bends occur.

The contract includes a length of nearly 44 miles, the longest on the canal. On account of the variable character of the material to be removed—7,090,000 cu.yd.—the excavation was divided into four classes or divisions: No. 1 comprising hard-pan, slate, shale and rock wherever occuring; No. 2 comprising the excavated and remaining rock of the so called State Ditch, east of Cross Lake; No. 3 comprising the cutoff bends, and No. 4 the channel excavation of the two rivers other than ledge rock, ranging all the way from the softest ooze, mud, silt, sand, muck, marl and clays, and comprising nearly one-half of the entire excavation, or 3,270,000 cu.yd. The contractor's bids for the four classes or divisions were respectively: $1.089, 56.1, 30.8 and 18.7c. per cu. yd.

For the removal of the soft material the contractors employ a hydraulic dredge, built by the Bucyrus Co., of South Milwaukee, Wis., which is named the "Geyser." The hull dimensions of the dredge are: length, 96 ft., beam, 29 ft. and draft, 9 ft. It will excavate material 19 ft. below the water surface and discharges its spoil at a distance of 1500 ft. through the pontoon pipes to a shore elevation of 25 ft. above water.

The steel A-frame at the bow supports the suction pipe and cutter head, the driving shaft and the gearing. The ladder is 33 ft. long and is pivoted at the inner end on one side of the elbow of the suction pipe and on the other side by a hollow pivot through which the cutter shaft is driven by a countershaft geared to a double 10x12-in. engine of 65 hp.

In the inboard suction pipe is a sluice provided with heavy bars to prevent large boulders from passing through to clog or break the pump. This latter is a 20-in. centrifugal, directly connected to a triple-expansion marine engine of 450 nominal hp., which will readily develop 550 hp. on overload. The pump is located about in the center of the hull, transversely to its length. The discharge pipe passes back on the port side to the stern, connecting with the pontoon pipe-line.

The boiler plant consists of two Babcock & Wilcox boilers, of about 230 hp. each, working under 160 lb. pressure. Duplex pumps are used to feed the boilers, to furnish water to the cutter-head bearing and for fire purposes. A 6-kw. generator supplies electric current for lighting purposes.

The line of pontoon boats which support the 20-in. discharge pipe is built and floated upon heavy watertight casks, placed underneath. The steel discharge pipe is in 32-ft. sections on the pontoons and 16-ft. sections on shore. Connections between the pontoon pipe sections are made by means of heavy rubber sleeves fitting over the ball-shaped ends of the pipe. The shore lengths are adjusted by simple telescoping, no sleeves being required. At the shore end a terminal pontoon is used for the purpose of raising the end of the pontoon line to connect with the shore line. This is done by a block and tackle and an A frame, which supports one end of the pipe. For the pontoon line about 600 ft. of pipe are provided and for the shore line 800 ft.

The "Geyser" was placed in commission on July 7, 1908, and worked until Dec. 5, 1908, when it was closed down for the winter. During this period of 5 months' work, the dredge excavated about 450,000 cu.yd. of material, the average monthly rate being 90,000 cu.yd.

The "Geyser" when built was intended only for use in the softer material, but early in its operation it encountered a quantity of cemented gravel. To expedite matters, the dredge was driven through this gravel with no adverse results beyond a decrease in the output and a more rapid wearing of the cutter. This, however, was remedied by the substitution of a much stronger cutter, weighing some 7000 lb., which answered the purpose. This cutter is 5½ ft. in diameter, by about 4 ft. long.

No record of the output of this dredge for the season of 1909 is available. While working near Brewerton, the dredge became stalled on a bar in the river on Sept. 26, 1909, making it necessary to undergo repairs, after which the dredge worked during October, 1909. On Nov. 5, 1909, the dredge broke a cutter and was closed down for the winter on Nov. 8, 1909, partly dismantled and placed in the repair shop. Repairs having been completed during the winter, the dredge resumed work on May 16, 1910, in the land cut above Three River Point, the junction of the Oneida and Seneca Rivers forming the Oswego, where fair progress was made until August, 1910. Hard material was then encountered, which required blasting ahead of the dredge. The progress, therefore, was very slow, only some 25,000 cu.yd. of material being excavated in October, 1910.

Progress during the following three months was slow. The "Geyser" was shut down on Jan. 24, 1911, for re-

pairs. Work was resumed in April, 1911, but repairs were necessary during August, 1911, and, work was finally shut down for the winter on Dec. 22, 1911. Work was resumed May, 1912, during which month about 65,000 cu.yd. were excavated in the Oneida

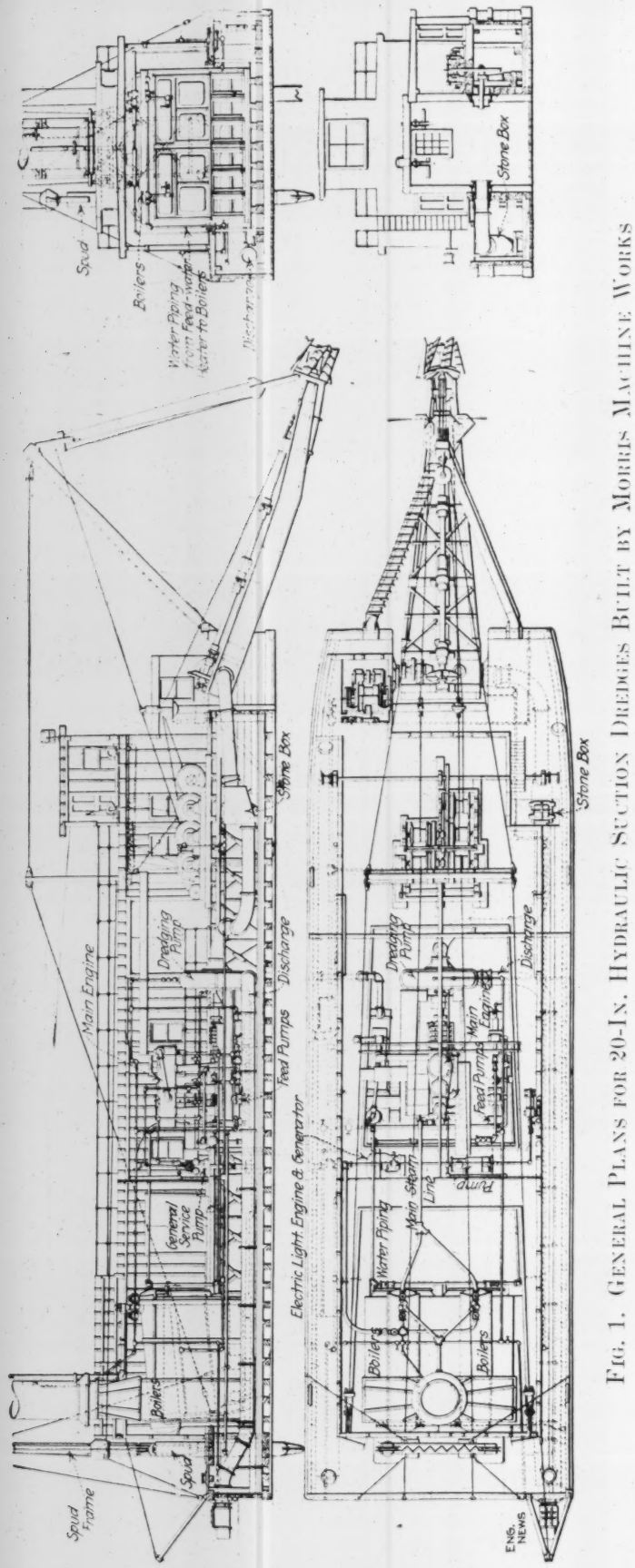


FIG. 1. GENERAL PLANS FOR 20-IN. HYDRAULIC SUCTION DREDGES BUILT BY MORRIS MACHINE WORKS

River, at Oak Orchard. During the month of June, 1912, the dredge worked intermittently, where material would permit; only about 38,400 cu.yd. was removed during this period.

DESCRIPTION AND WORK OF DREDGE "MONTEZUMA" ON CONTRACT NO. 46

Six hydraulic dredges were built by the Morris Machine Works of Baldwinsville, N. Y., for various contractors of the enlarged canals. All these dredges are steam operated except the "Fairport," which is electrically driven, the main pump being directly connected to a 750-hp. electric motor. The general plans for these dredges are illustrated in Fig. 1.

The first of these dredges, the "Montezuma," is operated by the Kinser Construction Co., of Chicago, on Contract No. 46, which extends from Fox Ridge to the southeast corner of the town of Galen. This contract lies in the well known Montezuma marshes, the outlet of the Cayuga and Seneca Lakes. The main item of the contract is excavation, the original estimate of which is 5,035,000 cu.yd.; the contract price was 17c. per cu.yd.

Contract No. 46, extends from Sta. 5203, which is about 1 mile east of the crossing of the New York Central & Hudson River R.R. to Sta. 5700, a distance of about 9½ miles. The depth of cutting on the first 2½ miles runs from 18 to 20 ft., the upper layer is muck and marl about 4 ft. deep, under which the material is fine sand, here and there some clay and hardpan. The second 2½ miles lies in the bed of the Seneca River, with cuttings ranging from 3 to 12 ft., the material being muck and marl, clay and sand. The last portion, about 4 miles, parallels the Clyde River, and is in its bed for a short distance at the western end; the cutting is 20 ft. east of Lock No. 25, and 14 ft. west of it. The material on the third section is much the same as on the first and second, with possibly more hardpan.

The hull of the "Montezuma" is 117 ft. long, 35 ft. beam and 8 ft. 6 in. deep, and is built of wood. The machinery equipment consists of a 20-in. all cast-steel dredging pump with 84-in. diameter runner, directly connected to a triple-expansion engine with cylinders 15x22½x36-in. diameter by 18-in. stroke. There are two Babcock & Wilcox water-tube boilers having 5000 sq.ft. of heating surface and built for 200 lb. steam pressure. The cutter ladder is made of steel and is 45 ft. long. The cutter engine is 12x12-in. double cylinder. The main cutter-shaft is 8½ in. in diameter. The hoisting engine was a 8x12-in. double cyclinder, with 5 hoisting drums. In addition the dredge contains the usual equipment, such as surface condenser, centrifugal-circulating pump, 7½-kw. electric generator set, and a full equipment of pumps for boiler feed and for general service.

The "Montezuma" was built during the spring of 1909 and began dredging operations on June 15, 1909, in the Seneca River at a place known locally as Kipps Island, west of Montezuma. The first half-month's output was 68,410 cu.yd., working three 8-hr. shifts in a cut about 22 ft. deep. The output for July was 121,242 cu.yd., for August 251,741 cu.yd., and for September 462,010 cu. yd.; this latter quantity established a new monthly record for hydraulic dredges on the enlarged canals.

The peculiar nature of the material is largely responsible for the large yardage. There was no vegetable growth to clog the pipes nor hard material to retard progress. The excavation was made to the entire width and depth of the prism and 4600 ft. long, the banks being low and practically level, and the spoil area ample and

contiguous, the discharge through the line of pipe was greatly facilitated. But one dike, the front one was required, the spoil being retained at the rear by the embankment of the adjacent Erie canal.

The output of this dredge during October, 1909, was only 176,293 cu.yd., due to hard material encountered at the site of Lock No. 25, where blasting was necessary. This same material retarded progress during November, only 19,030 cu.yd. being removed, but the output increased to 136,518 cu.yd. in December following.

The highest output during the year 1910 was in May, when 175,630 cu.yd. were excavated. With the exception of January and April, the output for the remainder of the year was much below the 100,000-cu.yd. per month mark, reaching only 19,313 cu.yd. in December, 1910. This was due to the hardness of the material, drilling and blasting ahead of the dredge being necessary. A much better showing was made during the year 1911, the dredge working north of the present Erie canal. During the month of November, 318,011 cu.yd. were excavated in the vicinity of the West Shore R.R.

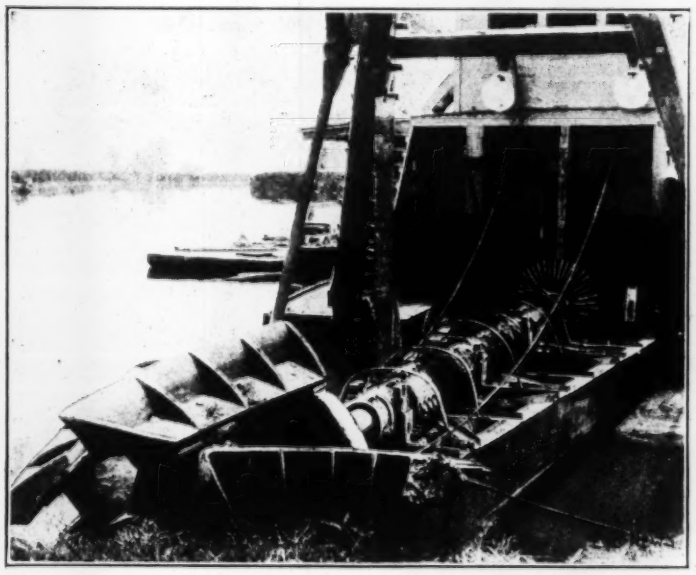


FIG. 2. CUTTER-HEAD OF THE DREDGE "MONTEZUMA"

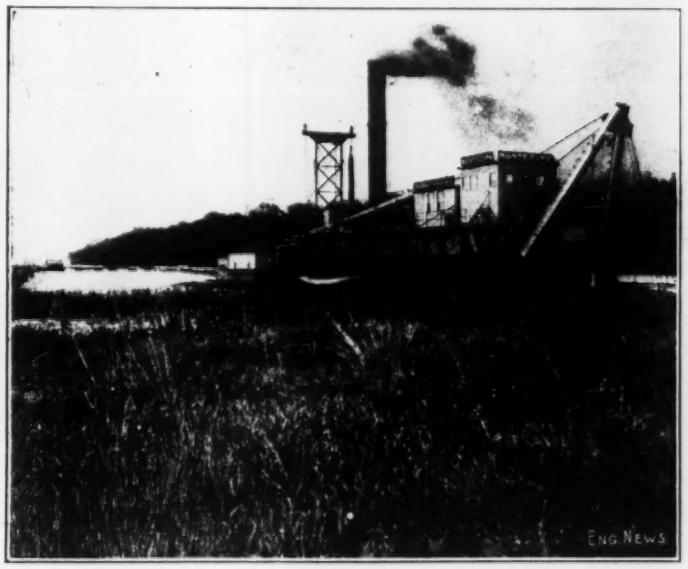


FIG. 3. DREDGE "MONTEZUMA" ON CONTRACT NO. 46

During the 7 months in 1909 in which the "Montezuma" was operated, the dredge excavated 1,235,244 cu. yd. or an average of 175,000 cu.yd. per month. For the 11 months of 1910, the figures are 915,850 cu.yd. and 83,000 cu.yd. and for the 12 months of 1911, 1,660,473 cu. yd. and 140,000 cu.yd., respectively. Figs. 2 and 3 show views of the "Montezuma" and give an idea of the character of the country traversed by this dredge.

WORK OF THE DREDGE "CLYDE" ON CONTRACTS NO. 47 AND *B*

Contract No. 47 adjoins No. 46 on the west and is in fact a continuation of the same, extending from the southeast corner of the town of Galen to Lyons, a distance of 14½ miles. The new canal parallels the Clyde River for the entire length of the contract, here and there occupying the bed of the river where straight reaches make this possible. The contract is essentially one of hydraulic-dredge excavation, the engineers' estimate of which is 5,310,000 cu.yd. The contract price is slightly higher than on No. 46, being 19.9c. per cu.yd. The contract was awarded Nov. 30, 1908, and is held by the Crowell-Sherman-Stalter Co., of Cleveland, Ohio.

The hydraulic dredge on this work is known as the "Clyde." It was built by the Bucyrus Co., of South Milwaukee, Wis., and assembled at Clyde, N. Y., which is located about in the middle of the work under contract. The construction of the hull commenced Mar. 27, 1909, and the dredge was launched May 1. The boilers, engines and fittings were installed after the dredge was launched. No derrick was used and all the machinery was placed by hand. The "Clyde" has a timber hull 101 ft. long and 34 ft. wide, the discharge pipe is 20-in. The main engine on the pump is 500 hp., and is operated by two Babcock & Wilcox water-tube boilers of 325 hp. each.

Actual operations were commenced with the dredge on June 28, 1909, in the river at Clyde. The object in starting at this point was to dig a channel deep enough to float the dredge, also for boating coal and supplies to deep water below. In order to do this the dredge was required to excavate at least 2 ft. below grade to secure flotation. Between Sta. 6029 and Sta. 6011+62, 17,000 cu.yd. of hard material was removed, which consisted of gravel, clay and soft shale. The gravel was cemented together with clay and formed a very hard crust on the river bottom above the shale.

A view of the spoil bank which shows how the cobble stones, boulders and shale rock were piled in places 10 ft. high in front of the discharge pipe is given in Fig. 4. After working 14 days, the contractors decided that it was not practicable to continue in this hard material as it seemed to be racking the dredge. The close cutter used, was doing the work without blasting but the wear on the fittings and the strain on the hull were too great to risk a new dredge at that season, for a serious breakdown might delay further operations for months. Work was stopped at this point until a temporary dam was built in the river 3 miles below and the water raised to a sufficient height to float the dredge over the bars.

The dredge then moved down to about Sta. 5886 and started in the Heit cut, July 19, and cleaned up the prism entirely to Sta. 6871+60 by July 31, removing about 126,000 cu.yd. in thirteen days, of which 111,415 cu.yd. was paid for material. The actual amount of material removed in July was about 140,000 cu.yd.

On Aug. 4, the "Clyde" encountered quite compact

gravel at Sta. 5868+64, and a very strong effort to clean to grade was not made. An inspector was put on the dredge at this time with instructions to keep complete records of lost time, performance of dredge and progress in the different kinds of material. His reports show, from day to day, the elevations at which loose gravel was encountered, also that which was more firm and compact.

After working a few days in the gravel, cracks began to show on the shell of the pump and they became so serious that it was evident the shell would not hold together much longer unless it was handling light material. Not having an extra shell on hand, the dredge crew was compelled to abandon the cut at Sta. 5854+30 on Aug. 22. From Aug. 1, the dredge had removed about 135,000 cu.yd., or about 6100 cu.yd. per day. This amount is not up to the average and I believe could

FIG. 4. SAMPLE OF STONES AND BOULDERS EXCAVATED BY HYDRAULIC DREDGE "CLYDE"

have been increased by using a shorter discharge pipe while in the heavy material. The wear and tear in this cut was, I believe, negligible, considering that in the first cut, the wear was extremely heavy; and any ill effects on the dredge noted were probably caused by this heavy first cutting.

The dredge was then moved back to Sta. 5887+50, below the lower approach for Lock No. 26, and finished up to the lock on Aug. 30. The material was mostly soft clay and 80,500 cu.yd. were excavated in 8 days. From the lock the dredge was moved down the river to Sta. 5810 and began working Sept. 2. On Sept. 10, at Sta. 5830+45, hard material was again encountered being the same as found at Sta. 5854+30. The new shell had not yet arrived and the dredge was compelled to turn back. Working but 14 days in this cut the dredge had removed 193,000 cu.yd. of material which included about 43,000 cu.yd. of gravel, making an average of 13,800 cu.yd. per day.

On Sept. 19, the "Clyde" began at Sta. 5810 and worked down stream in the river. At Sta. 5805, the line again enters a land cut and intersects the river at Sta. 5778. This cut was 3200 ft. long, contained 275,000 cu.yd. of soft clay and was completed in 23 days, an average of 12,000 cu.yd. per day. On Oct. 12, the dredge entered the river at Sta. 5778. From this point the river is canalized. Heavy gravel was encountered and two days were occupied in installing the new pump shell. Gravel and logs delayed the progress on the river stretch until on Nov. 9, when 88,000 cu.yd. of material had been removed, which included about 35,000 cu.yd. of gravel. An average of only 3200 cu.yd. per day was maintained. The remaining excavation, 1800 ft. long, containing 127,000 cu.yd. of soft material, was excavated in 10 days and completed Nov. 19.

The dredge was brought back to the cut which before had been abandoned and resumed operations again at Sta. 5830+40. With the new shell, it was thought possible to go through the hard material and clean up all work east of the lock. But the material was too hard and on Dec. 3, after making about 800 ft. and removing 70,000 cu.yd. of which 31,000 cu.yd. was gravel, the cut was abandoned for the second time.

The only excavation remaining in this contract which was suitable for a suction dredge was between Clyde and the east end of the contract, was located above the lock and this, amounting to 70,000 cu.yd., was completed on Dec. 17. All the work that the dredge was able to do east of Clyde was finished and it was tied up for the winter, for it was impossible to move it over the rifts at Clyde until the spring flood.

Of the 172 days from the time the dredge began work until it was tied up for the winter, 18 days were lost in moving and repairing, making 154 working days, in which 1,181,500 cu.yd. of material was excavated, including about 166,000 cu.yd. of heavy gravel; 1,037,605 cu.yd. was pay material, which ran about 12% under the actual work done. The average per working day for the season was 7668 cu.yd. and about 3½ miles of canal was completed.

The following is a résumé of the work performed by the "Clyde" during the season of 1909, all the material excavated being east of Clyde: During July about 106,000 cu.yd. and during August, 210,000 cu.yd. were removed. This was increased during September to about 250,000 cu.yd. In October, 1909, the quantity of excavation was 192,000 cu.yd., and in November, 220,000 cu. yd. The dredge suspended operations for the winter on Dec. 15, 1909, up to which date it had removed 60,000 cu.yd. of material.

Necessary repairs were made to the dredge during January and February, 1910, and dredging operations were resumed on Mar. 25, 1910. Hard material resulted in slow progress and during the remaining days of the month about 525 lin.ft. of prism were excavated, making 8000 cu.yd. of material removed.

The dredge continued to work westerly from Clyde towards Lyons, reaching the crossing of the West Shore R.R. at Sta. 6293+80, Aug. 21, 1910, and was held up here until Sept. 7, 1910, awaiting the completion of a temporary railroad bridge. After that, operations were continued well into the winter of 1910-'11.

Owing to the large output of this dredge it is of interest to give the following details for the year 1910:

Month	Excavation, (cu.yd.)	Prism, (lin.ft.)	
April	204,000	5225	
May	319,000	5150	
June	79,000	1300	hard material
July	361,000	5075	
August	267,000		West Shore R.R.
September	157,000		
October	254,000	3173	
November	343,000		
December	26,000		
Total	2,010,000		

During the season of 1910, the dredge completed about

5.9 miles of the canal, removing 1,858,000 cu.yd. of pay material. This amount is the record for the year for any one contract on the whole line of canal. In all, the dredge worked 235 days, of three 8-hr. shifts each, averaging 7900 cu.yd. per working day for the season, and occasionally removed as high as 24,000 cu.yd. in 24 hours.

The front dikes on the spoil area were built by a Browning excavator, which handled a 1½-yd. scraper bucket. The majority of the back dikes were made of planks, which lessened the cost and proved entirely satisfactory.

Notwithstanding the winter weather, the dredge continued operations during the months of January, February and March, 1911, the monthly outputs being small, 13,392, 9580 and 3000 cu.yd., respectively. During March, 1911, the "Clyde" was removed to Contract B, Cayuga and Seneca canal, which is also held by the Crowell-Sherman-Stalter Co. This contract is for excavating a channel mainly in the Seneca River from Montezuma to deep water in Cayuga Lake, and from Cayuga Lake to Seneca Falls, and from Waterloo to deep water in Seneca Lake. The length of canal prism in the contract is 17½ miles; the engineers' estimate of excavation is 6,400,000 cu.yd., and the contract price is 21c. per cu.yd.

The "Clyde" began operations on Contract B, on Apr. 7, 1911, and continued work until Jan. 14, 1912, when it was laid up for the winter. The extraordinary outputs on this contract are worth giving in detail:

Month	Excavation, (cu.yd.)
April, 1911	139,000
May	286,617
June	368,584
July	272,712
August	533,561
September	117,466
October	214,035
November	118,058
December	118,344
Total	2,167,377
January, 1912	107,105
April	228,842
May	218,545
June	138,130
July	230,243
August	153,871
September	336,333
October	268,666
November	90,998
December	8,520
January, 1913	61,927
Total	1,843,180

It will be noted that the output for August, 1911, was 533,561 cu.yd. of material. This enormous output constituted a new record for the work of suction dredges in the construction of the enlarged canals. The nearest approach to this record was made by the "Champlain" on Contract No. 25 in October, 1910, with a month's output of 500,352 cu.yd. Before that, the record was held by the "Montezuma" on Contract No. 46, which excavated 454,706 cu.yd. during September, 1909, under somewhat similar conditions to those encountered by the "Clyde." Fig. 5 shows a view of the "Clyde."

This work of the "Clyde" was performed in a section of the canal extending into Cayuga Lake, for a distance of about a mile north of the New York Central & Hudson River R.R. bridge. The cut was made for the full width of 200 ft. of channel prism and for a depth of 2 ft. below grade. Deducting this additional 2 ft., amounting to 152,880 cu.yd., the record of pay material still stands at 480,681 cu.yd. The spoil was pumped about 1500 ft. through a 20-in. discharge pipe to the west and spread over a large area.

Owing to repairs the output was reduced during the month of September, 1911, and again in November, 1911, when on the morning of Nov. 16, a tube in the boiler of the dredge exploded, killing four men employed by the contractors. The dredging was stopped for 10 days while the boilers were overhauled.

The operating cost of this dredge for one month is approximately as follows:

1 chief engineer	$150
3 operators	$125.00 = 375
3 engineers	100.00 = 300
3 oilers	70.00 = 210
6 deckhands	50.00 = 300
3 firemen	60.00 = 180
3 helpers	40.00 = 120
1 pipe-line foreman	125
17 laborers	40.00 = 680
Total	$2440
700 tons coal	2.50 = 1750
Supplies	300
Building dikes	2,500
Superintendence	510
Total	$7500

With an output of 200,000 cu.yd. per month with 24-hr. days of three shifts, the operating cost would be 3¾c. per cu.yd.

Work of the Dredge "Mohawk"; Contract No. 20-C

Contract No. 20-C is for dredging in the Mohawk River channel between Dam No. 9 at Yosts and Dam No. 10 at Canajoharie, a distance of nearly 8 miles. The engineers' estimate of excavation, the main item of work, is 1,100,000 cu.yd. The American Pipe & Construction Co. of Philadelphia, Penn., is the contractor; the contract price for excavation is 51c. per cu.yd. The section when completed will form the pool between the dams mentioned above, and also Locks Nos. 13 and 14.

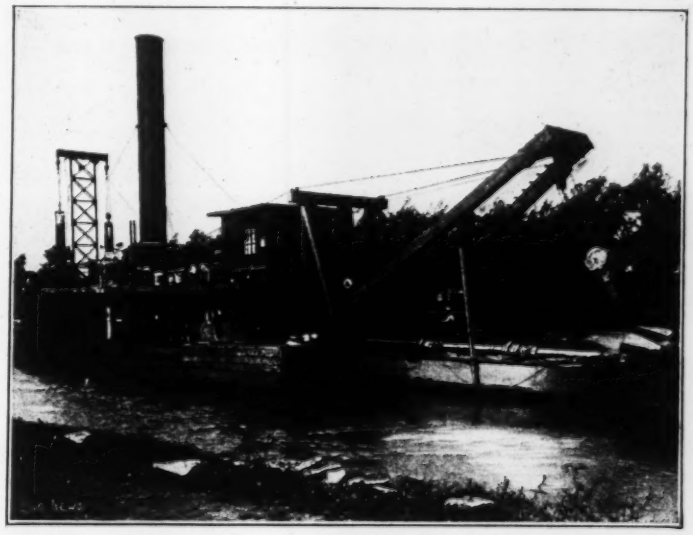


Fig. 5. Dredge "Clyde" Which Holds Record of 533,561 Cu.yd. per Month

The material to be removed on this, as well as on the adjoining sections, consists of small and large boulders, gravel and sand. To get an idea of the character of the material, the contractor in November and December, 1909, dug four test pits, from 6 to 9 ft. square and to the prism grade. The test pits showed that a large percentage of the material to be removed consisted of fine sand, which would have to be placed well back upon the shore and beyond the possibility of scour. Actual operations, however, developed that more stone and gravel existed than the test pits disclosed.

A hydraulic dredge, the "Mohawk," was built by the Morris Machine Works of Baldwinsville, N. Y., for this contract, and was put in operation in November, 1910. Soon after work was stopped by cold weather. During the following winter some alterations were made in the dredge, and it resumed the next season's work on Apr. 11, 1911, making a cut 80 to 90 ft. wide and depositing about 23,000 cu.yd. in spoil. Figs. 7 and 8 show views of this dredge. To show better the workings of

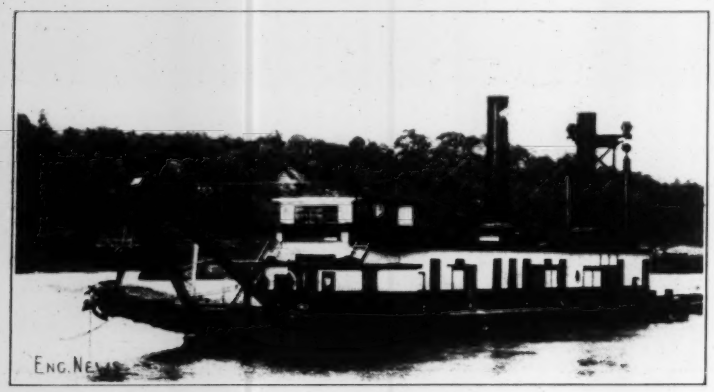


FIG. 6. DREDGE "AMSTERDAM" ON CONTRACT NO. 20-D

the "Mohawk," its monthly output is shown in tabular form below:

Month	Excavation, (cu.yd.)
April, 1911	23,000
May	
June	50,613
July	54,054
August	96,890
September	129,859
October	13,413
November	41,356
December	45,472
April, 1912	4,052
May	39,114
June	77,487
July	95,896
August*	55,328
September*	117,470
October*	206,645
November*	224,670
December*	18,123
Total	1,293,436

*The dredge "Mohawk" was engaged on Contract 20-D.

The quantities dredged are only those above the prism grade. In the softer places in the river, the dredge excavated large areas several feet below grade, to afford room for the disposal of hard material, excavated by a dipper dredge. This material was loaded on scows and dumped in the low places excavated by the hydraulic dredge.

DESCRIPTION OF THE DREDGE "AMSTERDAM" ON CONTRACT NO. 20-D

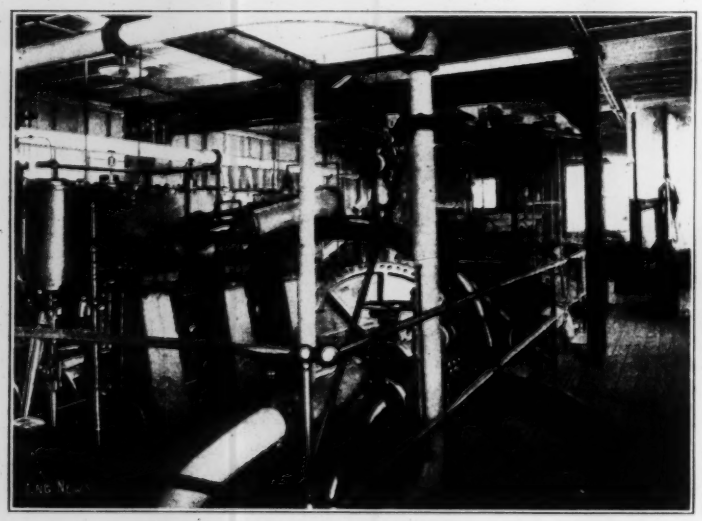
Contract No. 20-D is for channel excavation in the Mohawk River between the Rexford Flats aqueduct and Dam No. 9, at Yosts, a distance of 36 miles. The engineers' estimate of excavation, the main item of work, is 5,144,000 cu.yd. The contract is held by the American Pipe & Construction Co. of Philadelphia, Penn., the same contractor as for No. 20-C. The contract price is also the same for excavation, 51c. per cu.yd.

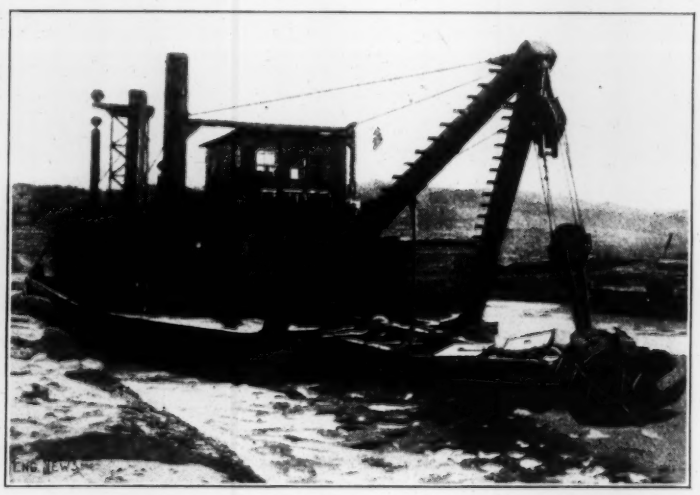
Hydraulic dredges can do most of the excavating, though some dipper dredge work will be needed. There is a considerable quantity of soft grade of rock included in the contract. A dipper dredge began operations May 18, 1911.

A hydraulic dredge, the "Amsterdam," has been constructed for this contract, the hull of which was launched in April, 1912. The machinery was installed by the Morris Machine Works of Baldwinsville, N. Y. The dredge hull is of wood, 137 ft. 8 in. long, 40 ft. wide and 10 ft. 2 in. deep. The ladder well goes into the hull 20 ft. 4 in. and is 16 ft. 6 in. wide. The main dredging pump has a 20-in. suction and discharge and is made throughout of manganese-steel with a runner 90 in. in diameter. The pump is directly connected to a three-cylinder triple-Expansion engine, with cylinders 17x27½x42 in. in diameter, all with a common stroke of 20 in. The engine operates with a steam pressure of 200 lb. and is capable of developing 1000 hp. It is of very heavy construction and built for high speed. The thrust bearing of the pump is water-cooled, and is of the marine type.

The suction and discharge piping within the hull is made throughout of manganese-steel; the piping is about 1¼ in. thick. There is a stone trap in the suction line to catch any material too large to pass through the pump.

The boiler equipment consists of four boilers built by the Heine Safety Boiler Co.; each boiler is rated at 225 hp. The boilers are arranged in two batteries, facing each other. Forced draft from a directly connected blower is employed in order to utilize an inferior grade of coal and in order to have short smokestacks. The con-





FIGS. 7 AND 8. VIEWS OF THE DREDGE "MOHAWK" ON CONTRACT NO. 20-C

denser equipment consists of a C. H. Wheeler condenser of 2000 sq.ft. of cooling surface. All steam is exhausted into the condenser except from a few of the smaller pumps which exhaust into the heater.

The air pump is of the vertical twin-beam type, size 7½x16½x10 in. There are two 8-in. Morris centrifugal-circulating pumps having 10-in. discharge and 10-in. suction, directly connected to an 8x8-in. vertical engine. These pumps are so arranged that either can be in service, one pump delivers to the condenser in one direction and the other in the other direction. Therefore by alternating the use of the pumps the condensers can be kept clear of any obstruction on the tube head.

There are two boiler feed pumps, each of vertical duplex Admiralty type, size 7½x5x6 in. There is also one water service pump of vertical duplex pattern, size 6x7½x6 in.; also a jet water pump ,of vertical duplex pattern, size 6x6x6 in. The feed-water heater is a Reilly multi-coil marine type and there is also a Reilly grease extractor, to remove any grease or oil from the feed water.

The ladder is 50 ft. long from the center of trunnion to front of cutter. It is made of steel throughout and is of very heavy construction, the depth of the ladder girder at the upper end being 42 in. The ladder shaft is 8½ in. in diameter with flanged coupling on the end, and is held in operating position by means of a multi-collar marine type thrust bearing.

The gears in the cutter drive are made throughout of cast-steel with cut teeth. The main driving gear on the ladder shaft is 14-in. face and 4-in. pitch. The cutter driving engine is a horizontal 12x12 in. double cylinder of very heavy proportions, and is designed so as to operate at about 225 r.p.m. with the cutter making about 12 r.p.m.

The cutter is of cast steel with renewable blades, and is attached to the cutter shaft on a 10-in. square end. There is a water-sealed ring joint at the upper end of the ladder in the suction pipe to give the necessary flexibility in raising and lowering the ladder.

The winding machinery consists of a Flory five-drum engine with double cylinders 8¼x12 in. The engine is compound geared. The ladder drum is 24 in. in diameter. The two swinging drums are each 20 in. in diameter, and the two spud drums 24 in. in diameter each. The gearing throughout is made of cast steel. The winding machinery is operated from a lever house arranged on the roof in the forward end of the dredge. The lever house also contains the gages for watching the operation of the main dredging pump.

There are two spuds, each 23 in. in diameter, with very heavy cast-iron points. The spuds are handled from a gantry frame made of structural steel and so arranged that the frame may be lowered for passing under bridges with little trouble.

There is a 15-kw. electric generator set directly connected to a 7x7-in. vertical engine. The swinging wires are wire rope 1 in. in diameter. The ladder hoist and spud hoist are also wire rope ⅞ in. in diameter. All sheaves are made of steel and are 30 in. in diameter.

This dredge began actual operations in July, 1912. During August it handled 92,532 cu.yd. of material, sand and extremely heavy and large gravel. A view of this dredge is shown in Fig. 5. Since its installation, the monthly output has been as follows:

Month	Excavation, (cu.yd.)
July, 1912	13,155
August	92,532
September	37,200
October	73,702
November	67,388
December	6,089

Work of the Dredge "De Witt Clinton" on Contract No. 30

Contract No. 30 is for dredging a channel in the Mohawk River a part of the distance and alongside the river the remaining distance, between Little Falls and Sterling creek, a distance of nearly 15 miles. The engineers' estimate of excavation is 5,095,000 cu.yd., for which the contractor, the Acme Engineering & Constructing Co., receives 33¾c. per cu.yd.

A hydraulic dredge, built by the American Locomotive Co., named the "De Witt Clinton," began dredging on Aug. 20, 1910. The following table shows the output of this dredge from the time of beginning to date:

Month	Excavation, (cu.yd.)	
September, 1910	156,060	
October	201,400	
November	118,413	
December	173,882	
		649,755
April, 1911	161,000	
May	75,900	
June	103,200	
July	245,100	
August	52,523	
September	135,000	
October	57,000	
November	22,200	
		851,923
April, 1912	62,089	
May	233,159	
June	167,000	
July	99,437	
August	193,504	
September	90,348	
October	53,839	
November	100,000	
December	7,544	
January, 1913	7,100	
		1,014,020
		2,515,698

The reason for some of the low monthly records is that very hard material was encountered, making progress slow and also causing considerable wear of the pumping machinery. In the case of some cuts as much as 4 ft. of material had to be left in the bottom to be removed otherwise. Much of this material was gravel and cobble formation.

The largest output was in July, 1911, when 245,100 cu.yd. of material was excavated and 2400 lin.ft. of prism partly finished, some 3 ft. of material being left in the bottom. Also at times it was necessary to dig below grade so as to float the dredge, water being held by temporary dams. The winter months were employed in making alterations and repairs to the dredge, which is a 20-in. suction type.

Work of the Dredge "Niagara" on Contract No. 19

Contract No. 19 is for that section of the canal between Tonawanda and the Sulphur Spring guard lock, and is 12½ miles long. It lies for its entire length in Tonawanda creek, with three exceptions, where three sharp bends are crossed. The main item of work is excavation, of which the engineers' estimate is for the rock section, 240,000 cu.yd., the contract price for which is 60c., and the earth section 2,842,000 cu.yd., the contract price of which is 17½c. per cu.yd.

In the beginning the work of excavation was done by means of a cableway, a Page excavator, a dipper dredge and two clam shell dredges, the plant being augmented

later by the addition of the hydraulic suction dredge, "Niagara," which was launched in June, 1909.

Its output for the season of 1909 was as follows:

Month	Excavation, (cu.yd.)
June, 1909	27,000
July	63,840
August	116,063
Spetember	70,345
October	69,351
November	187,558
December	55,907
Total	590,064

The normal working of the dredge was from 23 to 25 ft. from water level to the point of delivery. Operations for the season of 1910, were begun on Mar. 28, and the output was as follows:

Month	Excavation, (cu.yd.)
March, 1910	21,250
April	111,512
May	118,587
June	117,845
July	74,139
August	18,650
September	109,776
October	99,091
November	100,239
December	53,547
Total	934,537

During the month of April, owing to the immense weight of the spoil, the bank holding the same gave way and caused a large amount of material to slide back into the prism. A broken shaft during July caused a falling off in the monthly output. Up to this time the dredge worked in triple shifts.

For the season of 1911 the output per month was as below:

Month	Excavation, (cu.yd.)
April, 1911	31,000
May	74,652
June	26,231
July	113,289
August	36,410
September	27,700
October	20,301
November	17,980
Total	347,563

The small output was caused by working double shift only (two of 8 hours each), time lost on account of repairs, but principally because the material was very hard.

For the season of 1912, the output was also small, the dredge working double shift and rehandling material excavated by a dipper dredge; repairs also delayed the work:

Month	Excavation, (cu.yd.)
April	3,971
May	76,551
June	11,182
July	32,802
August	29,069
September	21,415
October	35,681
November	29,430
December	14,357
Total	254,458

Work of the Dredge "Fairport" on Contracts Nos. 63 and 49

Contract No. 63 extends from the Wayne-Monroe county line to Kings Bend. The amount of excavation on this contract is 2,772,000 cu.yd., the contract price is 33c. per cu.yd., the contractor is H. S. Kerbaugh, Inc., of Philadelphia, Penn.

An electrically operated dredge "Fairport" is in operation on this contract. Work began at the eastern end of the section under contract, in what is known as the Perrinton swamp on June 24, 1911.

The monthly output of this dredge has been as follows:

Month	Excavation, (cu.yd.)	
June, 1911	13,000	
July	80,000	
August	204,970	
September	98,000	
October	80,000	
November	90,376	On contract No. 49
December	59,993	On contract No. 49
March, 1912	18,270	On contract No. 49
April	133,583	On contract No. 49
May	31,414	On contract No. 49
Total	809,606	

This dredge was transferred to Contract No. 49 on November 13, 1911, continuing there until the middle of May, 1912, when it returned to Contract No. 63.

The material at the east end of the contract is sand which pumped easily, with an average output of about 7000 cu.yd. in 24 hours. In this material what is called an "open cutter" was used. Near Fairport a shale rock is encountered which runs in layers from 6 to 8 in. in thickness and is separated by a mud seam running about ½ in. thick. This material was removed by using a cutter with blades and teeth, which worked satisfactorily and broke up the material without blasting, but with small output, averaging about 1800 cu.yd. per day. We have no record of the dredge "Fairport," June, 1912, to date. Owing to hard material the output was very small.

Work of the Dredge "Stanwix" on Contract No. 43

Contract No. 43 is for that part of the canal which extends from Oriskany to Rome, paralleling the Mohawk River. The engineers' estimate is 5,017,500 cu.yd. of excavation; the contract price is 18c. per cu.yd. and the contractor is M. A. Talbot Co., of Baltimore, Md. This contract comprises the work on the eastern end of the Rome summit level, which extends from Oriskany on the east to the village of New London, on the west.

A hydraulic dredge, built by the Morris Machine Works, of Baldwinsville, N. Y., called the "Stanwix," operates on this contract and its monthly output is given below:

Month	Excavation, (cu.yd.)
July, 1911	86,258
August	95,740
September	135,919
October	73,259
November	77,561
December	35,624
January, 1912	47,454
February	17,288
April	20,000
May	86,675
June	93,681
July	145,696
August	90,464
September	53,566
October	83,800
November	105,673
December	60,750
Total	1,309,408

The following is a statement of the operations of the dredge "Stanwix," from July, 1911, to July, 1912: The dredge was launched in July, 1911, and started work at Sta. 6156, at Mill St., Rome, and worked east to the easterly crossing of the New York Central & Hudson River R.R., at Sta. 6097, and returning reached Sta. 6156 about the middle of December, 1911. After passing under the newly constructed Mill St. bridge and reaching Whitesboro St. in the early part of February, 1912, the dredge was put out of commission for two months. The present Erie Canal was cut through in April, 1912, and in the middle of July the westerly crossing of the New York Central & Hudson River R.R., at Sta. 6228

was reached. Working again eastwardly, the dredge has been excavating a 225-ft. widewater between Lawrence and James Sts.

The material east of the Erie canal is coarse gravel running out to muck west of James St. Practically all the material was pumped into embankment, 425 ft. south of the canal for the relocation of the New York Central & Hudson River R.R. This embankment ranged from 10 to 20 ft. in height and is 85 ft. wide on top. The material is discharged between dikes thrown up by Lidgerwood excavators.

Delays, aside from time consumed in passing under bridges and through the Erie canal, were caused by the necessity of replacing the pump shells which were twice worn through by the gravel, which delayed operations for about two days each time. Delays were also caused by the necessity of repeatedly heightening the dikes west of the Muck road. The softness of the material excavated here caused the dikes to break down very often.

The output as shown above does not represent the quantities actually excavated as a great deal of the fine material was deposited on the canal bottom west of Mill St. from the return water, and during July and August, 1912, there was a large amount in the widewater for which the contractor was not paid.

Work of the Dredge "Palmyra" on Contract No. 77

Contract No. 77 is for the construction of the new canal from Port Gibson to Palmyra. The engineers' estimate for excavation is 2,657,980 cu.yd., for which the contract price is 38c., the contract being held by the T. A. Gillespie Co., of Pittsburgh, Penn.

A hydraulic dredge named the "Palmyra" commenced operations on July 6, 1911. The following table shows its output from that time to date:

Month	Excavation, (cu.yd.)
July, 1911	14,274
August	35,000
September	63,753
October	243,766
November	67,681
December	60,000
January, 1912	8,264
February	26,966
March	30,445
April	95,972
May	58,467
June	166,972
July	64,180
August	44,427
September	72,100
October	11,742
November	71,542
December	39,559
January, 1913	43,000
Total	1,107,110

The following statement shows the cost of operating this dredge one month, working three shifts of 8 hours each:

1 captain		$250
1 chief engineer		175
3 engineers	$150.00	450
3 levermen	150.00	450
3 mates	100.00	300
6 firemen	70.00	420
3 oilers	70.00	210
13 deckhands	60.00	780
1 pipe line foreman		125
26 laborers	1.75 per day, 26 days	1183
Total labor cost		$4343
Miscellaneous expenses, fuel, etc.		1657
Total		$6000

Assuming the monthly output as 60,000 cu.yd., the operating expenses per cu.yd. would be 10c.

The following, relative to the character of the material on Contract No. 77, has been furnished by M. J. Coffey, Superintendent for The T. A. Gillespie Co.

When the dredge started to work in the year 1912, there was a loam on top for about 4 or 5 ft. in depth, but underlying this was a bed of boulders, many of them so large that they would not go through the dredge, which greatly hampered the working of the dredge, cutting down the output to almost nothing, as well as causing some breakdowns. Then a ledge of very hard material was encountered in the bottom, which was practically rock. The canal line follows the valley of Mud creek: the stream is very crooked and the canal crosses it a number of times.

In October, 1911, and June, 1912, the dredge was working in pretty good material for a hydraulic dredge—loam and sand, in som ecases practically a quicksand.

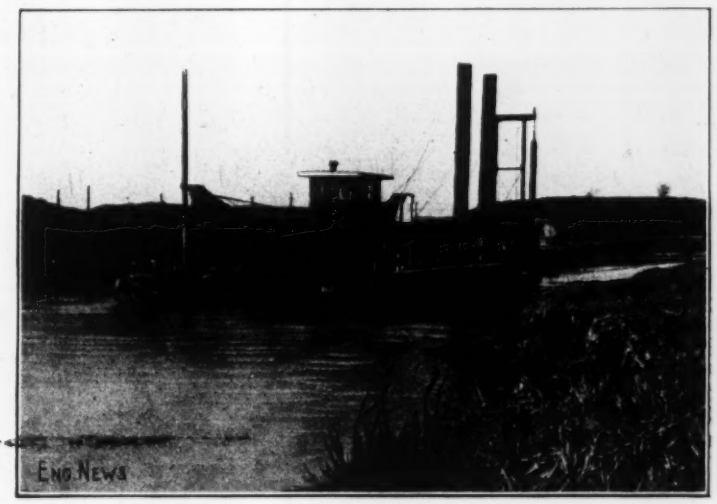


Fig. 9. Dredge "Lyons" on Contract No. 48

The discharge pipe line varied in length anywhere from 1200 to 4000 ft. The long pipe-line was necessary because the spoil is discharged on lands appropriated by the state for this purpose, which was not always alongside the prism.

Work of the Dredge "Lyons" on Contract No. 48

Contract No. 48 is for that part of the canal extending from Lyons to East Newark. The engineers' estimate of excavation is 2,002,500 cu.yd., for which the contract price is 48c. The contractor is the Crowell-Sherman-Stalter Co., of Cleveland, Ohio.

A suction dredge named the "Lyons" was launched on Aug. 31, 1911, and commenced work on Oct. 24, 1911. The "Lyons" (Fig. 9) was built by the Bucyrus Co., of South Milwaukee, Wis. Its operations were confined wholly to the eastern end of the contract, east of Lock No. 28-A where the material is muck, red clay, sand and gravel. The dredge "Lyons" operated until Sept. 15, 1912, and was then laid up for repairs. The following is the monthly record of its operations:

Month	Excavation, (cu.yd.)		
October, 1911	11,067	12,696	dredged on contract No. 47
November	191,360	11,745	
December	46,683		
January, 1912	50,774		
February	41,030		
March	88,963		
April	153,871		
May	140,200		
June	40,000		
July	53,000		
August	63,000		
September	23,000		
Total	902,948		

Description of 20-in. Hydraulic Dredge of the "Lyons" Class

The following is a detailed description of a Bucyrus dredge of the same general type as the "Lyons" but slightly less in power:

HULL—Steel, 104 ft. long by 34 ft. wide and 9 ft. deep. The dredge is adapted to dig to 22 ft. below water level with ladder inclined to 40° and discharges through 1500 ft. of floating and shore pipe at a height of 25 ft. above water level.

DREDGING PUMP AND ENGINES—The pump has a 20-in. inlet and discharge. The runner is 78 in. in diameter. The casing and heads are of nickel-chrome-steel castings and are made very thick where the greatest wear comes on them. The casing is not lined. The runner is a single nickel-chrome-steel casting having five curved arms mounted on a forged steel shaft 8 in. in diameter. The pump is direct connected to a vertical triple-expansion marine type engine of 520 hp. running 230 r.p.m. and has steam cylinders 13½ in., 20 in. and 33 in. by 16-in. stroke.

CUTTER HEAD—The cutter head is a single nickel-chrome-steel casting 5 ft. 10 in. in diameter and has six blades and renewable cutting edges fastened to the inside of the blades. It is mounted on a forged-steel shaft 7¾ in. in diameter and is driven by a 10x14-in. double engine through heavy steel gearing.

OUTBOARD SUCTION PIPE—The outboard suction pipe is of 20 in. in inside diameter made of lap-welded steel pipe ½ in. thick, having a suction head on the outboard end with bearings for supporting the cutter-head shaft. It connects with the inboard suction pipe through two cast-steel elbows, one of which revolves on a horizontal axis. The pipe will be braced by structural framework hinged to the bow of the hull. The inboard discharge pipe is lap-welded steel ½ in. thick in the straight stretches with cast-steel elbows. Between the pump and the intake pipe a stone box is provided with a manhole to permit removal of any stones stopped by the grating at the pump intake.

DISCHARGE PIPE—The inboard discharge pipe is of lap-welded steel pipe ½ in. thick. The outboard discharge is ⅜ in. thick riveted in 20-ft. sections, having a total length of 700 ft., and is provided with rubber sleeves and floated on pontoons. The remaining 800 ft. are provided with telescopic joints for shore disposal. The pontoons are of the barrel type, consisting of four large water-tight hogsheads connected by timbers upon which the discharge pipe rests, but with sufficient deck to facilitate working on the pipes.

WINCH AND OPERATING LEVERS—The winch is driven by double engines having cylinders 8½ in. in diameter by 8-in. stroke and has five drums, two for the swinging line, two for handling the spuds and one for raising and lowering the suction pipe. It is also provided with two winch heads, which can be used for handling scows, etc. The operating levers are concentrated in the pilot house so that the machine can be operated by one man.

SPUDS—There are two steel spuds, 22 in. in diameter, having sharp chisel-shaped steel points.

DECK SHEAVES AND FAIR-LEADS—All necessary sheaves and fair-leads were furnished. The sheaves are all made of steel and are 24 in. in diameter.

BOILERS, FEED PUMPS—Two Babcock & Wilcox boilers, having a heating surface of 2350 sq.ft. each and adapted to work at 160 lb. pressure are provided. Two feed pumps of adequate size are furnished and were fitted with connections so that they may be used for fire purposes or for washing decks. One surface condenser, having 1250 sq.ft. of cooling surface is furnished, with the necessary circulating and air pumps and feed-water heater.

BILGE PUMPS—Six steam siphons and a connection from the circulating pump with the inside of the hull were furnished for removing the bilge water. The connection from the circulating pump to the inside of the hull was one that could be used in the case of an emergency. The steam siphons were quite able to take care of any ordinary leak in the hull that might occur.

ELECTRIC-LIGHT PLANT—An engine and dynamo capable of supplying current for 100 incandescent lamps, together with the necessary instruments mounted on a slate switchboard are furnished.

INCIDENTALS—Pump and piping to provide water for bearings of main engines and dredging pump and for cutter-head shaft bearing in suction head are furnished. Also the necessary whistles, bells, speaking tubes, gages, etc.

In addition to the hydraulic dredges enumerated above, there were dredges of this class employed on Contracts Nos. 20-A, 30, 41 and 42 of the Erie canal and Contracts Nos. 27, 72 and 73 of the Champlain canal. The suction and discharge of all these dredges are 12 in., except on Contract No. 30, where a remodeled dipper dredge has a 16-in. discharge, and on Contract No. 73 where the size is 20 in. In addition there are a number of dipper dredges engaged on various contracts, there being four employed on Contract No. 12.

On Contract No. 20-B there is a so called hydraulic disposal boat, material being supplied by two dipper dredges, the large stone discharged into scows and the finer material pumped ashore. Two ladder dredges are at work on Contract No. 12, the "Cyclone" and the "Tornado," on Contract No. 60, the "Mohawk," and on Contract No. 66, the "Mineola." The monthly output of the ladder dredges is not large, being about 25,000 cu.yd. That of the dipper dredges has reached as high as 50,000 cu.yd. per month, while the monthly output of the smaller hydraulic dredges is from 15,000 to 27,000 cu. yd. per month.

A Typhoid Epidemic Caused by Uncalked Joints in an Intake Pipe*

By W. M. Cobleigh†

During the summer of 1909 a typhoid fever epidemic broke out among the railway employees in Laurel, Mont. There are two water systems supplying the city. One furnishes water to the people living in the original townsite, and the other furnishes water to the residents of a new addition built by the Northern Pacific R.R. There were about 100 cases of typhoid fever in the railway addition, and the older part of the town was practically free from the disease. This fact and other circumstances quickly indicated that the water-supply of the addition was the source of the infection.

This water-supply is taken from the Yellowstone River through a cast-iron intake pipe which delivers the water to a large brick-lined pump well. A pumping plant at this well forces the water to tanks in the railway yards a mile away.

A sewer system discharges into an irrigation canal at a point near the pump well and the sewage flows in an open ditch directly over the cast-iron intake pipe and as the ditch overflowed at times a large area of soil was polluted.

The intake pipe from the river became partially clogged with sand and there was in consequence a shortage of water in the well. To increase the water-supply in the well, surface water was piped into it from a point above the sewer outlet for a few days only. Two or three weeks after this a typhoid epidemic began. The infection could have come either from this surface water, or from ground water contaminated by sewage entering the intake pipe through uncalked joints. The writer was called on to report on the sanitary condition of the water system.

Samples were analyzed of the river water at the intake and of water from one of the tanks in the yards. The results were as follows:

	First test Parts per million		Second test Parts per million	
	Intake	Water tank	Intake	Water tank
Total solids	164	740.	182.	611.
Free ammonia	.03	.13	.05	.05
Albuminoid ammonia	.17	.09	.13	.15
Nitrogen as nitrites	Trace	.0091	.0036	.0024
Nitrogen as nitrates	Trace	.22	Trace	.23
Chlorine	6.1	14.8	1.5	9.5
Sulphates as SO_4	25.0	350.4	12.1	300.4

A comparison of the results indicates very plainly that the pumps were not delivering pure river water to the tanks. The high solids, sulphates and chlorides indicated that ground water was entering the system in large quantities and that it was no doubt contaminated, as shown by high free ammonia and nitrites. In this connection it should be stated that the well and the intake pipe line were located in wet ground highly charged with "white alkali," which is high in sulphates.

In a report to the railway company the writer stated that the ground water entered the system either by seepage into the well or by leaks in the intake pipe line. The company officials, having confidence in the construction of the pipe line, decided that the well was the cause of the trouble and therefore connected the intake pipe directly to the pumps so as to pump water directly from the river. When this change was completed analyses were again made and proved that ground water was still entering the system and that a faulty pipe line was no doubt the cause. To locate the position of the leaks in the line, the pumps were stopped and water from the tanks was allowed to flow through the pipe to the river. In a few minutes the water appeared on the surface of the ground over the intake pipe.

This intake pipe was then dug up where the leaks were evident and it was found that the cast-iron pipe had been laid for a distance of about 400 ft. without calking the joints.

The leaky joints in the pipe line were calked and the pumping plant was put in shape to deliver to the tanks river

*Abstract of a paper prepared for the annual meeting of the Illinois Water Supply Association, March 11, 12, 1913.

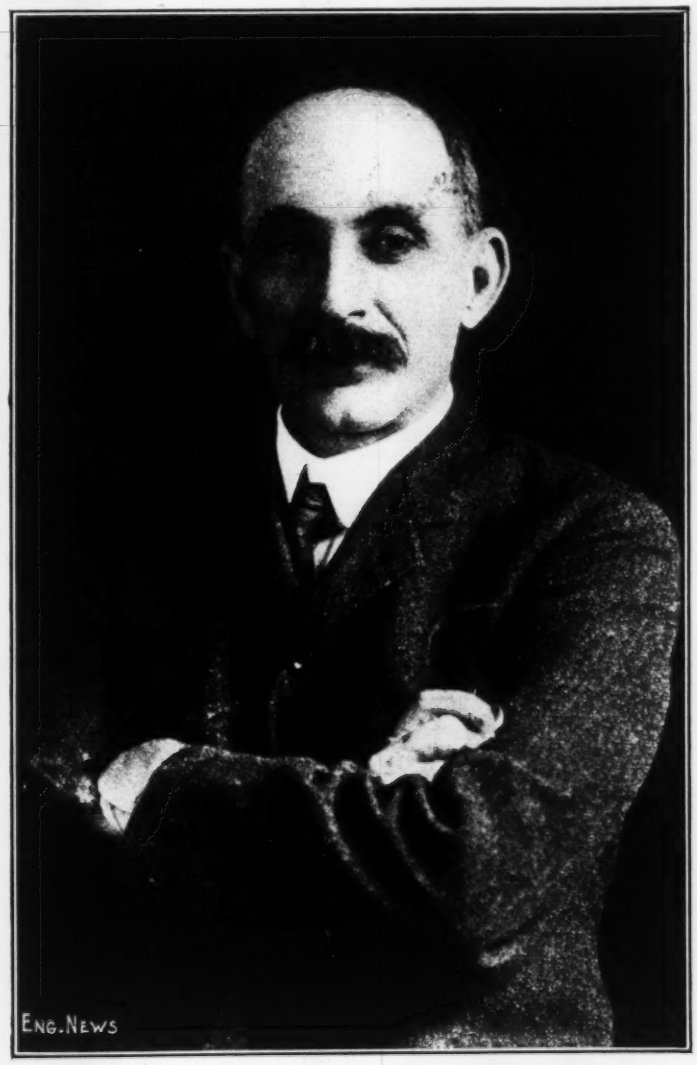
†Professor of Chemistry, Montana State College, Bozeman, Mont.

water which was not contaminated by ground water. The system has been in use for domestic purposes now for several months and no typhoid fever or enteritis has been reported since the repairs were completed.

In justice to the engineer who put in the water system for the railway company, it should be said that when the plant was first started, it was intended to supply water for engine use only. The intake pipe line was not calked because it was intended to be used as a gravity line; but the fact that this line was in wet ground high in white-alkali was overlooked as was also the possible effect of the sewage disposal system on the purity of the water.

Ira N. Hollis, the New President of Worcester Polytechnic Institute

Announcement has been made that the trustees of the Worcester Polytechnic Institute, Worcester, Mass., have elected Prof. Ira N. Hollis, of Harvard Uiversity, President, to succeed Dr. L. L. Conant, Professor of Mathematics, who has been Acting President since the resignation of Dr. Edmund A. Engler, two years ago.



Prof. Hollis was born near New Albany, Ind., in 1856. He was educated in the public schools of Louisville, Ky., and after a year's work as apprentice in a machine shop and foundry, he was appointed to the U. S. Naval Academy at Annapolis, Md. He graduated at the head of his class in 1878 and was appointed a member of the Engineer Corps.

The succeeding 15 years were spent in various work in the Navy, both at sea and on shore. After service at the Union Iron Works, San Francisco, Calif., in the inspection of machinery, he went to sea as Chief Engineer of the U. S. S. "Charleston," then the flag-ship of the Pacific Squadron. One of her long voyages was the well remembered chase of the filibuster "Itata," a merchant ship taken by the insurgents in the Chilean War, and loaded with arms in California. At Iquiqui, where she was surrendered to the American fleet, Lieut. Hollis volunteered for service in her, and for his work was commended officially to the Navy Department by Admiral McCann.

He returned to the United States in the "Itata," which was delivered to the United States Marshal at San Diego, Calif., in July, 1891.

In January, 1892, he was ordered East and served under the late Rear-Admiral Melville until October, 1893, when he resigned to take the Professorship of Engineering at Harvard University.

During the summer of 1892 he delivered a short course of lectures at the Naval War College on "The Ships of Our Modern Navy." These lectures were afterward issued to the service in book form.

At Harvard he was charged with the duty of developing the engineering instruction, and he remained at the head of the Department for 16 years. It was during these years that he did much work in connection with student activities, in that way coming into intimate relation with student life outside of the class-room. He was Chairman of the Athletic Committee for seven years while Soldiers' Field was being turned into a recreation ground for the students. During this time the whole field was regraded, and the boat house, the ball cage and the Stadium were built.

Prof. Hollis has also been for many years a trustee of the Harvard Union, and a director of the Cambridge Trust Co., the bank where many professors and students have their deposits.

In 1898, Prof. Hollis was associated with Rear-Admiral Wainwright in the reorganization of the personnel of the Navy, and the bill written by them was used as a basis for action in Congress. He has served twice on the Board of Visitors at the Naval Academy.

In 1899, he received the honorary degree of A. M. from Harvard and has since received honorary degrees from other institutions. He is President of the Engineers Club of Boston, Vice-President of the American Society of Mechanical Engineers, Past-President of the Boston Society of Civil Engineers, and has served on the Council of the American Academy of Arts and Sciences. He is a member of the Society of United States Naval Engineers, the Society of Naval Architects and Marine Engineers, the Society for the Promotion of Engineering Education, and the Massachusetts Military Historical Society. He has contributed many articles to engineering and naval journals, and in intervals of leisure he wrote the "History of the Frigate Constitution." The final summing up of his career at Harvard is best shown by an abstract of the student editorial of the "Harvard Crimson."

The announcement that Prof. Ira Nelson Hollis has been elected president of Worcester Polytechnic Institute makes Harvard men rejoice at the signal honor that has been bestowed upon him, but it also brings them intense regret because it means the loss of a great teacher and steadfast friend. The admiration with which all Harvard men regard him illustrates the influence a teacher of strong personality may wield when he tries to know and serve his students outside the class room.

A New Type of Sewage Sedimentation Tank, Mount Washington, Md.

By Howard T. Oliver*

The latest method of treating sewage is that in operation at Mt. Washington, Baltimore County, Md. The process consists of a thorough sedimentation in a tank so arranged with baffles and compartments that the more heavily loaded waters at the bottom are retained a longer period; the deposited sludge is siphoned off to be deodorized in a separate chamber, while provision is made to disinfect the effluent after leaving the tanks. At present the effluent is discharged from the sedimentation tank to the neighboring stream in a stable condition, because of the efficiency of the tank in removing 80% of the settling solids and the fact that the sedimentation takes place near the source of the sewage.

Speaking generally, the problem of sewage disposal will be simplified if the process of sedimentation be allowed to take place near the source of the sewage; there will be a greater percentage of solids removed and there will be less organic matter in solution after the removal, for, the farther that sewage travels: the more broken become the solids and the less their subsiding value; the more colloidal forms of no subsiding value there are; and the more bacteria and organic matter are released to solution. Removing the solids near the source permits a higher degree of sedimentation, gives a greater opportunity for the absorption of atmospheric oxygen, and relieves any necessary final treatment of a large percentage of overburdened and unstable waters.

The type of tank used at Mount Washington seems especially adaptable to the idea of separating the solids early in the course of the sewage: the space occupied is small; the cost of construction and maintenance is relatively low; the percentage deposition effected is high; the inlet and outlet may be at the same level; and the tanks may be built underground and so be placed anywhere within a sewer system.

There are few cities where it would be impracticable to group sections of 40,000 to 80,000 population so that the sewage might be treated in a fresher condition to give better and cheaper results.

Mount Washington is a residential suburb covering about two square miles north of the city limits of Baltimore. The present population is about 5000. The sewage is entirely free of trade wastes or other complications and is carried to the plant in separate sewers of 24-in. and 12-in. mains (see view, Fig. 1). The plant is now owned by the County of Baltimore, having recently been purchased from The Baltimore Suburban Sewage Disposal Co. This company constructed the tanks, following designs and directions of Messrs. A. H. Wehr, of Baltimore and M. J. Wiest, of Govans, Md. The plant is at present operated under the supervision of Mr. Wiest. It is neat and compact, the effluent is clear, and there is a complete lack of odor about the premises; built of reinforced concrete, it does not give an unattractive appearance to the neighborhood.

Referring to the plan (Fig. 2), it will be noticed that on leaving the sewers the sewage flows through an 8-ft. channel into a grit chamber for the removal of sand deposits; this chamber has a plain V-shaped section 4 ft. deep and 8 ft. long, and is cleaned out weekly. From the grit chamber the waters pass through bar screens for the removal of débris; for this purpose bars ¼ in. thick are placed with a clearance of 1 in. and leaned slightly downstream. Bypasses have been provided for emergencies of sudden increased flow to carry the waters directly to the tanks.

Each unit is one tank (Fig. 1), but divided by partition walls into eight compartments. The first compartment serves as inlet and outlet, these being separated by a longitudinal baffle which extends through all the compartments, but is cut away in the last to allow the stream to return on the outlet side. This center baffle does not extend to the bottom of the tank, but terminates in a flared end, 5½ ft. above the bottom, in such a way that the upper waters are divided, but the lower waters of the influent and the effluent join. Other longitudinal baffles, on either side of the center baffle, extend from the top of the tank vertically to the level of the outlet, then flare inwardly to near the center baffle. These tend to a greater displacement of the waters and to prevent lateral

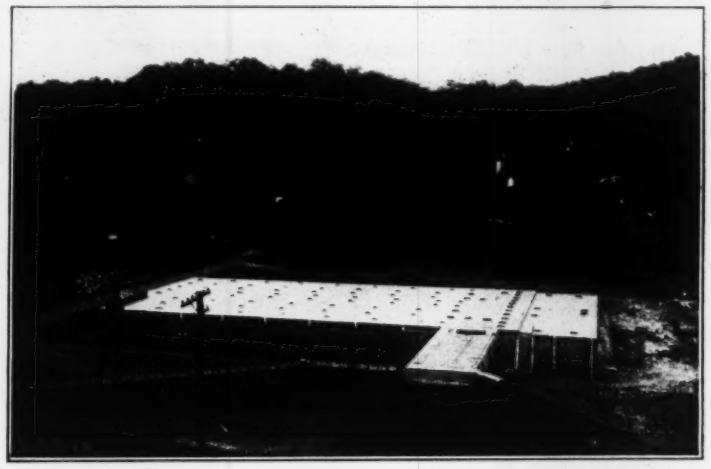


Fig. 1. View of Sewage Sedimentation Tanks, Mount Washington, Md.

and vortexual motions; they also serve, to a large extent, to hasten the deposition of the solids, for in any up and down movement of the sewage in the tank the particles have only a partial opportunity to rise again to the surface and to be carried on.

The sewage enters the first compartment between the displacement baffle and the center baffle, but enters the second compartment over the partition wall on both sides of the displacement baffle and so continues through each compartment to the last from where it passes to the outlet side of the center baffle and returns to the first compartment; here the outlet is confined to the space between the center baffle and the displacement baffle on the far side.

Each compartment is provided with bottoms sloping downward from each side toward the center, providing an increased floor space and retention chamber for the deposited solids. In each compartment there is a siphon which serves to carry off the sludge from the floor to a connecting pipe line, thence to the sludge deodorizing basin; each individual siphon is provided with a valve to regulate the flow of the sludge. In the center of each compartment, extending downward from the tank cover, are braces running across the current, but so far as tending to disturb the solids or to direct the greater displace-

*Engineer, 149 Broadway, New York City.

ment of the waters they serve rather as scum boards, preventing the carrying of these matters through the tank. Manholes give entrance to each compartment and are provided with covers to prevent the escape of any odors.

After leaving the sedimentation tank, the effluent is at once released to the creek for dilution, having no need for further clarification. The stream which receives the effluent has a normal flow of about 25,000,000 gal. a day, a volume quite sufficient to maintain the stability of the sewage delivered from this district even if it were received in a raw state. For experimental purposes, the designers of the plant at Mt. Washington constructed a small sand filter box and chemical tanks for any further treatment of the effluent that might be desired. The sand box serves as a means of partial oxygenation to the waters, but because of the comparatively small filtering surface the greater value of the box will probably be found in its further removal of "fines." The results of experiments with the sand box and certain mechanical "scrubbers" are withheld. From the sand box or directly from the sedimentation tank the effluent may pass directly to tanks where, if necessary, chemicals may be added. The designers of the plant are prepared to add ferric salts in these tanks in case of a saturation of H_2S; also, if it should become necessary or advisable to destroy the bacteria content, they expect to use hypochlorite.

The sludge which is deposited on the floor of the tank is siphoned off about every two months and conveyed by gravity through a 12-in. pipe to a digesting chamber, 10x10x6 ft., where it is treated with a deodorant. The designers of the plant refuse to disclose what chemicals or what particular products they use for this purpose and how they are applied, so it can only be stated here that the results attained are most satisfactory. There is no appreciable odor and no flies or insects are present.

After the process of deodorization the sludge is spread over the ground, in the open air to dry, and is then sold as fertilizer. The dried sludge contains practically its original content of organic matters in the form of nitrates, nitrites and phosphorus, is odorless and harmless. Individuals who have used the final product for fertilization have spoken very highly of the results obtained by its use in a small way. These facts point to a practical method of disposing of sludge in a way to prevent odors and to prevent the transference of intestinal bacteria by insects or air currents; and because of the impossibility of organic decomposition, the old idea of using sludge as a fertilizer is again revived.

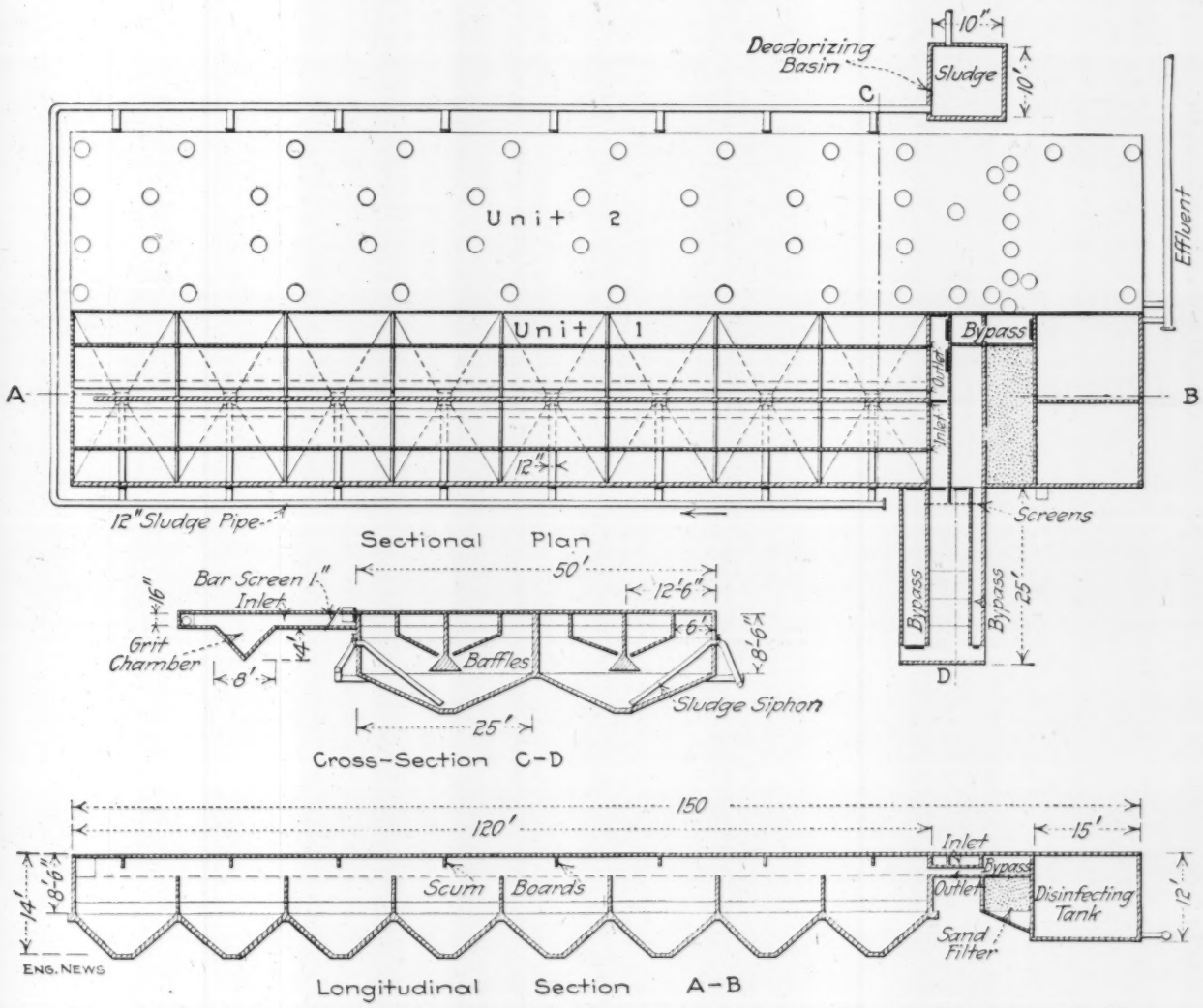


FIG. 2. PLAN AND SECTIONS OF SEWAGE SEDIMENTATION TANKS, MOUNT WASHINGTON, MD.

The Mount Washington plant will eventually consist of two units, each containing eight compartments, as shown in the plan and longitudinal section, Fig. 2. At present only one unit is in operation. The principal dimensions of each unit, with capacities of compartments, units and total, together with other selected data are shown in the following tabulation:

Overall dimensions	150x50x14 ft.
Width of each compartment	48 ft.
Length of each compartment	15 ft.
Capacity of each compartment	50,250 gal.
Capacity of each unit	402,000 gal.
Capacity, total	804,000 gal.
Present sewage volume	50,000 gal. at 100 gal. per capita daily
Percentage extraction of the solids	80%

The effluent is completely stable; there is no septic action in the tanks; there is no odor about the plant.

The results obtained are all that could be asked, but unfortunately the probable efficiency of the tanks as applied to population of from 40,000 to 80,000 can not be determined from these statements. At 50,000 gal. a day, it would require about eight days to fill the compartments of one unit; this means that the deposition of the solids occupies eight days, more or less, dependent on the "coefficient of retardation" of these particular tanks. It is entirely impracticable to determine this coefficient with the small volume of sewage now being treated. To know the normal flow or degree of stillness of the tanks, larger volumes must be tested.

The tank arrangement, however, endeavors to utilize several principles involved in some of the later theories of a maximum deposition of the solids under conditions least likely to result in bad odors. The large floor surface tends to allow the solids less horizontal movement, while its shape tends to prevent disturbances in the sludge already deposited. The arrangement of the tank walls and baffles seems to produce in actual practice an unusually high displacement of the waters with a minimum of internal disturbances.

A better arrangement of the sewer entrance would permit the elevation of the outlet to be the same as the inlet, which in this case is raised in order to permit the flow of the sewage to the second unit past the effluent from the first.

Remembering that the inlet and the outlet are in the first compartment, but on opposite sides of the center baffle, and that this baffle does not reach the bottom by about 5½ ft. at the center, it seems evident that there will be a short circuit established which will permit the sewage to pass out in the effluent. This would, of course, defeat the purpose of the tanks. By observing the course of an analine dye during a number of tests it was determined that 10 min. longer were required for the color to show in the effluent by passing under the central wall than by following its regular course through eight compartments and return. Thus: time required in the regular course, 60 min.; time required in short circuiting, 70 min.

There is an important advantage in the short center baffle which seems to overbear the objections to permitting any of the sewage to leave the prescribed course by short-circuiting: the sludge which is deposited beneath the wall is constantly surrounded by the clarified waters which have returned, so that only aërobic conditions are maintained about the sludge, making septic action in it very unlikely. Also supposing that a small portion of the entering sewage does flow out there is an equal amount returning for further clarification or to aid in decreasing any possibility of septicization.

The general action seems to be that of a comparatively rapid surface velocity with a long retention of the main body of the water. Using an analine dye as a basis of observation, the velocity of the surface is about 1 in. per sec.; if this velocity were maintained in a shallow, flat bottomed tank, the efficiency of the deposition would be extremely low, for there not only the surface is moving, but a large percentage of the body with it.

The most effective sedimentation is obtained by holding in one place as much of the sewage as long as possible, not in endeavoring to reduce the surface velocity or the velocity of the mass by the use of immense tanks. The Mount Washington plant procures an 80% sedimentation with a surface velocity of 1 in. per sec., but requires more than eight days to replace the whole body while large tanks, covering acres, are compelled to be built large enough to permit a velocity of less than 0.5 in. per sec. to procure a 60% deposition. This statement is only intended to show that sedimentation depends on holding each portion which needs it, unusually still, to allow the solids to settle, allowing a rapid run-off of the upper waters which have been clarified.

These arrangements of the walls and baffles deserve a thorough consideration and tests with large volumes of sewage, for theoretically, and practically in a small way, they fit in with the most modern ideas of obtaining a thorough sedimentation. If it can be proved that similar construction, of no greater size than 150x50x14 ft., can even obtain as low as a 50% sedimentation, handling the sewage from sections of 40,000 to 80,000 population, it will pay to install a number of them underground, in the very midst of a city, if only to relieve the final treatment; no odors could be released and the final effluent would be less unstable and less objectionable to be released at once for dilution in rivers, lakes, or bays. The use of some such method of sewage treatment would be especially valuable to conditions such as exist in Mexico City: a low water-supply giving a heavily charged sewage, a low velocity in the sewers, and an overburdened drainage canal having to carry the solids for miles, makes their removal at short intervals almost obligatory in order even to remove the effluent.

The Mount Washington plant could be duplicated for $27,500 per unit; each unit to accommodate a population of 40,000. The annual cost per unit of maintenance should not exceed: supplies, $2000; labor, $1800; total, $3800. There should be no odors in the vicinity of the plant. The sludge should be a source of income as a fertilizer if treated with a satisfactory deodorizer.

The effluent could be released either to a final filtration or to a final dilution, separated from a high percentage of the solids because of the possibility of introducing the process of sedimentation close to the source of the sewage.

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The Use of Chlorine or Hypochlorites for disinfecting potable water is reviewed editorially in London "Engineering," for Feb. 7, 1913. After discussing the general subject and giving some data (mostly well known here) for Toronto, Ont., and other places, the article concludes as follows:

Thus, in many parts of the world chlorine has been used in drinking water with excellent results, the number of bacteria being reduced to safe figures and sometimes even to zero, and the B. communis coli being almost entirely removed, as far as plate tests on large quantities of water could determine. It is satisfactory to know that we have such a process which can easily be applied at very short notice to stamp out a water-borne epidemic, should accidental contamination of a supply occur. At the same time it is not clear that a British community would accept it except as a remedy in an emergency. The evidence as to taste is conflicting, and even if some of the complaints are due to imagination, an outcroy would soon be raised here against water which had been treated with strong chemicals, first to sterilize it and then to remove the taste. As far as we can see, the slow filter is likely to remain the sheet-anchor of the water engineer, either alone or in conjunction with roughing filters of the Puech-Chabal type, although mechanical filters using a precipitant such as sulphate of alumina are exceedingly useful in some places, particularly where the water is highly colored with humic, crenic and apocrenic acids, as often occurs when it is derived from the peat of the upland moors found in the North of England. As to processes depending on ozone and ultra-violet rays, further practical experience is needed before their exact commercial value can be determined, although the former type is in use in several places on the Continent.

Methods of Estimating Stream Flow When Streams Are Frozen

By W. G. Hoyt†

Since the publication of my paper on "Gaging Minnesota Streams in Winter," I have had numerous requests for information regarding the methods employed in making computations of flow of water in ice-covered streams. I therefore submit the following notes on this subject:

The usual methods of obtaining daily discharge of streams under open-water conditions may be briefly given as follows: Daily gage heights are obtained from a gage maintained at a permanent datum. Current meter measurements are made to determine the flow at different stages of the river. The results of these measurements are plotted with gage heights as ordinates and discharge in second-feet as abscissas. A curve is drawn through these plotted points and the daily discharge is obtained by applying the mean daily gage heights to the curve. If the channel is fairly permanent, such a curve will remain constant and measurements made from year to year will plot in close proximity to it.

When the temperature falls below freezing, numerous conditions affecting stream flow are liable to be produced which tend to destroy the otherwise fairly constant relation between stage and discharge, thus making it necessary to employ special methods to arrive at the true daily discharge. (Fig. 1.)

Measurements of discharge which indicate the flow at the time they are taken are fundamental in any method for winter estimates. The accuracy of the results will depend largely on the frequency of the measurements, and, in connection with records of gage heights, temperature, precipitation and ice conditions, they form the basis for estimates of flow.

Precipitation is the cause of all runoff, and since temperature is the controlling factor in regulating the rate at which winter precipitation reaches the streams, it follows that temperature is, in general, the most important governing factor and should be given special consideration in making winter estimates of runoff.

Estimates of stream flow under winter conditions may be made by the following methods:

1. By the application of the gage heights of the water surface to the open-water rating, when it is known that the controlling point for the gage is clear of ice and that no backwater exists at the gage.

2. By developing a curve based on discharge measurements and gage heights to the water surface to which is applied directly the open water-gage heights as taken by the observer.

3. Basing the flow directly upon discharge measurements, taking into account the climate, ice conditions and gage heights.

(a) By the eye method, working directly with the daily discharge, varying it between times of measurement by inspection of the temperature and precipitation records and gage heights, and adjusting by comparison of results for nearby stations.

(b) By applying the open water rating to the gage heights and applying to these discharges a coefficient as determined at times of measurements, varying the coefficient according to a knowledge of temperature, precipitation and ice conditions.

(c) By the graphic method, plotting the records of temperature, precipitation and gage heights to the water surface and determining the amount of correction necessary to apply to the gage heights in order that the open-water rating table may be used, basing the variation in this correction between times of measurements directly on the variations in gage heights and temperature conditions and modifying the same by record of precipitation and ice conditions.

The accuracy of Method 1 depends primarily upon the location of the station. Stations are now located at several points in the United States and Canada at which this method is giving excellent results, but, as their number is few, the method can only be used in special cases.

The accuracy of Method 2 will depend largely upon the number of discharge measurements and their conformity to a true curve. It is believed that this method can be used at former stations than can Method 1.

The methods described in No. 3 will apply at practically all gaging stations which are affected by ice conditions. Method 3(a) is the one now commonly used, but is is believed that 3(b) and 3(c) will give better results than 3(a) and that Method 3(c), which is described more fully hereafter, has an advantage over either 3(a) or 3(b).

A discharge measurement taken under ice conditions, when plotted to the open water gage heights (Fig. 1),

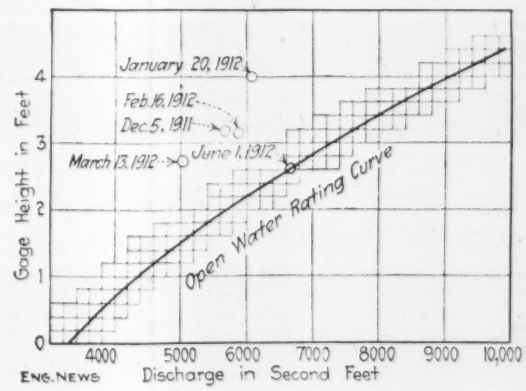

Fig. 1. Open-Water Rating Curve for Rainy River at International Falls, Minn.

(The curve is based on a large number of current meter measurements and plotted winter measurements showing how relation between stage and discharge is destroyed by ice conditions).

will always plot either on the open water curve or to the left, showing that the disturbing conditions result in a backwater effect. Therefore to arrive at the true flow for a given gage height it is only necessary to determine the magnitude of this backwater effect at the gage. Since the formation of ice is due entirely to climatic conditions, it follows in general that the amount of backwater varies directly with climatic conditions.

Having determined accurately the amount of backwater at stated intervals by discharge measurements, it is possible to determine the backwater effect between times of measurement by constructing a curve of backwater. Such a curve can be drawn by following the observed gage heights and the climatic and other conditions which cause the backwater.

The development of this method has been largely based on studies made during the winter of 1911 and 1912 on the Rainy River, at International Falls, Minn. At this point there is a regular current meter gaging station just below the plant of the Minnesota & Ontario Power & Paper Co. The Canadian Department of Public Works determines the flow at the plant by means of wheel ratings and the same flow is also computed by the U. S. Geological Survey at its regular gaging station.

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*Permission for publication given by the Director of U. S. Geological Survey.

†District Engineer, Water Resources Branch, U. S. Geological Survey, Old Capitol Building, St. Paul, Minn.

The average monthly variation in flow, as determined by these two methods during the five months from June to October, 1912, was 0.75%.

The Rainy River, for some miles below the power plant, has a very slight slope, so that notwithstanding the fact that this part is usually free from ice, due possibly to the presence of acid from the paper mill and to

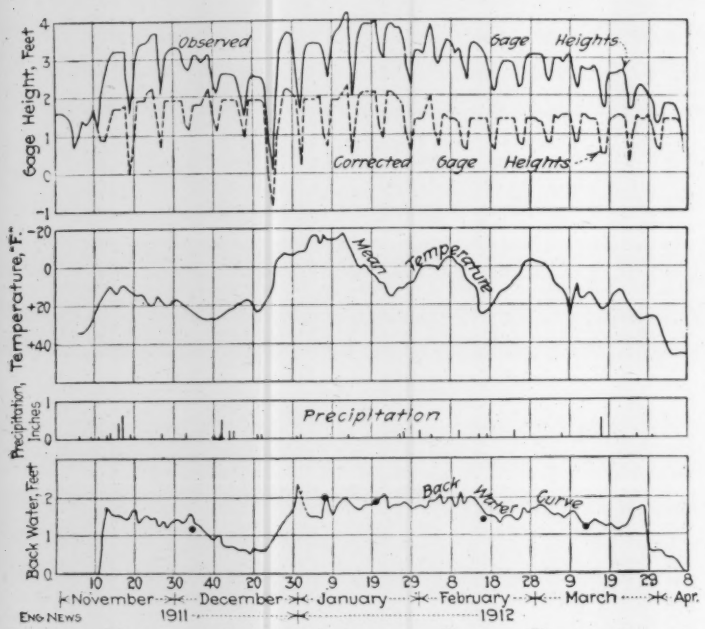


FIG. 2. VARIOUS OBSERVATIONS AT RAINY RIVER GAGING STATION, INTERNATIONAL FALLS, MINN., NOV. 1, 1911, TO APR. 8, 1912

(The observed gage heights have been corrected on the basis of the backwater curve. The mean temperature was averaged in 5-day periods. The backwater observations were taken at the gage. The full circles on and near the backwater curve indicate dates of current meter measurements).

the agitation of the water as it passes through the wheels, there is more or less backwater effect due to the formation of ice which occurs below the open water stretch.

We have therefore at this point a gaging station which is so affected by ice that the regular methods of computation of daily discharge do not apply, and also a station where the true daily flow is obtained, so that data are available for studying the effect of the ice. This study has been made graphically on Fig. 2, which shows the following curves:

1. The observed daily gage height for the gaging station below the dam.
2. The corrected daily gage height obtained by using the rating table for the station below the dam and finding the daily gage height corresponding to the daily discharge given by the records of flow through the plant (no water passes over the dam).
3. The mean daily temperature at the gaging station.
4. The daily precipitation at the gaging station.
5. The daily backwater effect obtained by taking the difference between the observed and corrected gage height curves, which shows the amount which the recorded gage height reading should be corrected to give a gage height which will, when used with the open water rating table, give the true discharge.

A study of the mean temperature curve and the backwater curve shows that these two curves tend to follow the same general direction, which confirms the assumptions previously stated. This is also borne out by records at other stations, and it is therefore believed that this relation will hold on the average stream, unless it is destroyed by unusual precipitation or ice conditions; that is, ice jams which cannot be taken into account in the construction of the backwater curve.

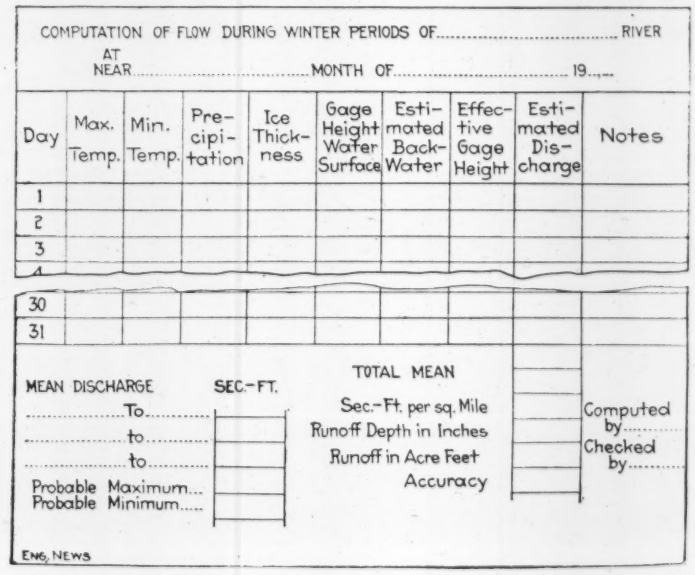
Based on this assumption, it is possible to construct the backwater curve from a comparatively few measurements of discharge distributed through the period affected by ice from which the backwater effect on the days on which they are taken can be obtained. By plotting these values as ordinates and days as abscissas under a daily temperature curve, it is possible to draw a curve through the point so plotted, following the same general shape as the temperature curve, which will give the backwater conditions for each day. In drawing this curve, account should be taken of the daily precipitation and of ice jams or other unusual conditions which may introduce backwater effect.

The circles plotted with the backwater curve (Fig. 2) show the backwater as determined from the discharge measurements on various days during the period in question. If these and the temperature records had been the only data available, a backwater curve could have been drawn which would have approximated the true backwater curve which was obtained from the daily records of flow over the dam. Of course care must be taken to study all the possible conditions which may affect the estimates.

Aside from giving more accurate results, this method has an advantage over any other method that has been devised, in that it gives a complete record of all the steps taken, so that the estimates may readily be reviewed or checked by a second person and show at once exactly how they were prepared.

The data necessary for use with this method are:

1. Daily gage heights observed to the water surface through a hole made in the ice if the section is frozen over.


COMPUTATION OF FLOW DURING WINTER PERIODS OF..... RIVER
AT
NEAR..... MONTH OF..... 19....

Day	Max. Temp.	Min. Temp.	Precipitation	Ice Thickness	Gage Height Water Surface	Estimated Back-Water	Effective Gage Height	Estimated Discharge	Notes
1									
2									
3									
4									
30									
31									

MEAN DISCHARGE SEC.-FT.
.....To.....
.....to.....
.....to.....
Probable Maximum...
Probable Minimum.....

TOTAL MEAN
Sec.-Ft. per sq. Mile
Runoff Depth in Inches
Runoff in Acre Feet
Accuracy

Computed by.....
Checked by.....

ENG. NEWS

FIG. 3. SUGGESTED FORM OF SPECIAL COMPUTATION SHEET FOR RECORDS AND ESTIMATES OF STREAM FLOW BENEATH ICE

2. Records of daily temperature at the gaging station.
3. Record of mean precipitation over the drainage area above the gaging station.
4. Measurements of discharge* at intervals during the period when frozen conditions existed.

*See "Eng. News," Sept. 12, 1912, for methods of making.

As already stated, the accuracy of this method will depend upon the frequency of these measurements. If the winter conditions are more or less constant, less fre-

quent measurements will be required, as it is during periods of thaws that the principal uncertainties occur. Regardless of this method, a special computation sheet should be used and some fairly standard method followed, which will bring winter estimates on a standard basis so that full records may be had. The headings on the typical card given in Fig. 3 are suggested for such a form.

In connection with this study, I wish to advance the following tentative conclusions, based upon observations of conditions in Minnesota since the Fall of 1911:

1. Ice conditions usually cause backwater at the gage.
2. Backwater increases rapidly at the beginning of each cold period, partly dropping off later.
3. The amount of backwater will tend to vary with the temperature.
4. Stream flow will drop off suddenly, following a cold period, and will be partly regained later.
5. Stream flow tends to decrease when temperatures go below 32°, but the flow tends to increase with any rise in temperature, especially when the minimum temperature goes above 32° F.
6. A snow cover on the ice may cause increased backwater.
7. Flow may increase without a rise in gage height, due to the wearing away of the ice.

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Railway Construction and Train Tonnage*

By R. N. Begien†

SYNOPSIS—A railway is built for the purpose of carrying trains, and with the increasing demand for operating efficiency and economy it is of increasing importance to know what maximum train-load an engine will haul under required time-table or schedule conditions and under the conditions due to the physical characteristics of the division. The determination of these loads on a scientific basis is effected by tonnage-rating systems. The size and power of the locomotive itself are important factors, but the factors of the physical characteristics of the road are equally important and the paper given herewith shows very clearly the relations between train tonnage and these characteristics (which include profile and grades, curves, tracks, etc.). Conversely, it may be said that the physical characteristics of new lines are limited by prescribed operating conditions as to train-loads and speeds. Consequently, the railway engineer (in location, construction and maintenance) is vitally interested in the operating conditions as well as in the engineering problems of his road or division.

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Proper tonnage rating is that load which can be hauled by the locomotive over the road at an economical speed. Owing to factors which are, in a measure, indeterminate, it is not an exact science. Strictly economical tonnage rating would be different for every train, since no two engines or cars are in the same condition. Road conditions differ on different parts of the same division, and some men are better and more uniform performers than others. Perfect uniformity of mechanical and roadway conditions would result in large economies in the way of a decreased number of trains due to increased tonnage per train. Where it is impossible to secure perfection, uniformity pays well, even if it costs money to get it.

MAINTAINING THE NORMAL PROFILE

Railway profiles change in the course of years. Fills settle, causing sags in the grade line. The raising of tracks through cuts is cheaper than ditching, but is responsible for summits in cuts. The sequence of raised cuts and depressed fills causes a wide variation from the original ruling grade. On some lines it has been found that stretches of 0.3% grade have become 1%. If places of this character occur near a point of heavy resistance, an immediate effect on the tonnage of a train is the result. Such places may cause the stalling of a train, and in a short time the frequent delays will result in decreased tonnage rating. [In the accompanying cut, the correction of grades shown by the upper line of the profile would allow about 25% increase in the tonnage rating for slow freight trains.]

Raising tracks is not as economical as is sometimes believed. While better drainage is undoubtedly secured, it is generally better practice to clean the ballast, and widen cuts to secure a ditch, and to raise track only when it becomes necessary to put roadbed to a proper line and surface. On such occasions, grade stakes should be used to establish the grades. On many roads an effort has been made to place permanent monuments, so that the track could be kept at a constant elevation. The difficulty of maintaining monuments along a roadbed is well known. They are not only likely to be a menace to the lives of the trainmen, but they are constantly settling, and being knocked by section men, and occasionally by derailments. However, the importance of placing permanent monuments cannot be overestimated.

COMPENSATING GRADES ON EXISTING TRACK

Compensation of grade for curvature is not vital to small trains running at speed. The resistance due to curvature is principally felt by heavy-tonnage trains on ruling grades where the engine is rated at a high percentage of its cylinder tractive power. Various experiments have been made to determine how much reduction in grade would compensate for the added resistance of curvature. It has generally been the practice to compensate this at a stated amount, and, while this method is not as accurate as could be desired, it is very much better than no compensation at all. From considerable observation of the influence of curvature, together with the examination of numerous tests of its effect, it is felt that some rules can be laid down which will improve the present practice.

1. Compensate 0.3% per degree: (A) when the length of curve is less than half the length of the longest train; (B) when a curve occurs within the first 20 ft. of rise of a grade; (C) when curvature is in no sense limiting.

2. Compensate 0.035% per degree: (A) when length of curves is between 50 and 75% of that of the longest train; B, when the curve occurs between 20 and 40 ft. of rise from the bottom of the grade.

3. Compensate 0.04% per degree: (A) where the curve is habitually operated at low speed; (B) where the curve is longer than 75% of length of the longest train; (C) where superelevation is excessive for freight trains; (D) at all places where curvature is likely to be limiting.

4. Compensate 0.05% per degree where the loss of elevation can be spared.

An illustration will show what can be accomplished by compensation of curvature on old roadbeds: Take a grade of of 0.5% five miles long, with an average curvature of 60° per mile, without compensation. If the maximum curve is 6° and the curve equal in length to the longest train, the curvature will have the same effect in limiting tonnage as a grade of 0.24%. This, added to the 0.05% grade, would make a ruling grade of 0.74%. The effect of the curvature on the five miles of grade would be 300°, which, at an average of 0.035% per degree, would amount to 10½ ft. If this 10½ ft. is added to the 132 ft. of rise in the five miles of grade, it will be equivalent to 142½ ft., or 28½ ft. to the mile, which is equal to a grade of 0.54%.

If this latter compensated grade is laid so as to be superimposed immediately above the present roadbed, it will be found that by reballasting the track to permanent stakes on this grade, a new ruling grade can be established, which will be 0.2% below the 0.74% equivalent to the 0.5% uncompensated grade. On a grade of this length, it will be possible to haul nearly 25% greater tonnage per train, thereby secur-

*Abstract of a paper on "Dynamometer Tests on the Baltimore & Ohio R.R., and Their Application to Tonnage Rating," forming an appendix to the report of the Committee on Economics of Railway Location, presented at the annual convention of the American Railway Engineering Association, at Chicago, Mar. 18-21.

†Assistant General Superintendent, Baltimore & Ohio R.R., Baltimore, Md.

ing a very large economy in operation for a small expenditure of money.

COMPENSATION OF LOW GRADES.

The effect of curvature on low grades (level stretches and up to 0.3%) is generally greater than on heavy grades, provided the length of train is what would be justified by the low grade. On double-track roads, particular attention should be paid to curves (whether uphill, downhill or level) at places where steam is being taken by the engine in moving in either direction. On virtual level grades each track should have its tangents slightly raised and its curves slightly sloping down hill, so that the pull by the engine may be uniform, and the resistance of the line constant. The value of keeping the line resistance constant becomes more important as the length of the train increases.

One of the prime objections to hauling a long train is the danger of parting, and in this danger curvature plays an important part. If the line has many short curves, it is usual for the slack of the train to be constantly taken up and let out. If the engine runs out on straight track; when the rear of the train is bunched on the curves, it will accelerate faster than the other end of the train. Unless the engineman is watching, and using the brakes slightly, he may pull out a drawbar. On the other hand, if the front end of the train is on a curve, and the rear end on straight track, the tendency is for the rear end to run in on the front end, and break a knuckle. It should not be supposed that it is impossible to have different classes of compensation on each track of a double-track railway.

SUPERELEVATION ON CURVES

From a scientific standpoint (not always from a financial view), it is evident that a six-track road is the most desirable for a railway that handles a three-speed service. This will give a passenger track, a fast freight track, and a slow freight track in each direction. It becomes necessary for a train to stop occasionally on a curve, and for that particular case the superelevation is always wrong. As no superelevation is necessary at very low speeds, it may be eliminated entirely on tracks that are used exclusively for standing cars, and very low superelevation (if any) should be used in yard tracks.

On a single-track road carrying more than one class of traffic, there are two ways to treat superelevation: 1. Make the freight tonnage rating as great as possible, and in accordance with the ruling grade; in this case, it will be necessary to elevate the curves for freight speed, and run the passenger trains slowly over ruling grades. 2. Use a higher superelevation for passenger speeds, and decrease the tonnage rating to make up for the increased resistance caused by the wheels of the freight trains binding against the lower rail.

Single-track roads which are crooked can rarely haul as high a percentage of rating as double-track roads, on account of the superelevation being wrong, for it is easy to see that every down-grade becomes an up-grade for movements in the opposite direction. As the movement downhill is likely to be faster than it is uphill, the superelevation must be made for the downhill movement or speed limits introduced on downhill trains.

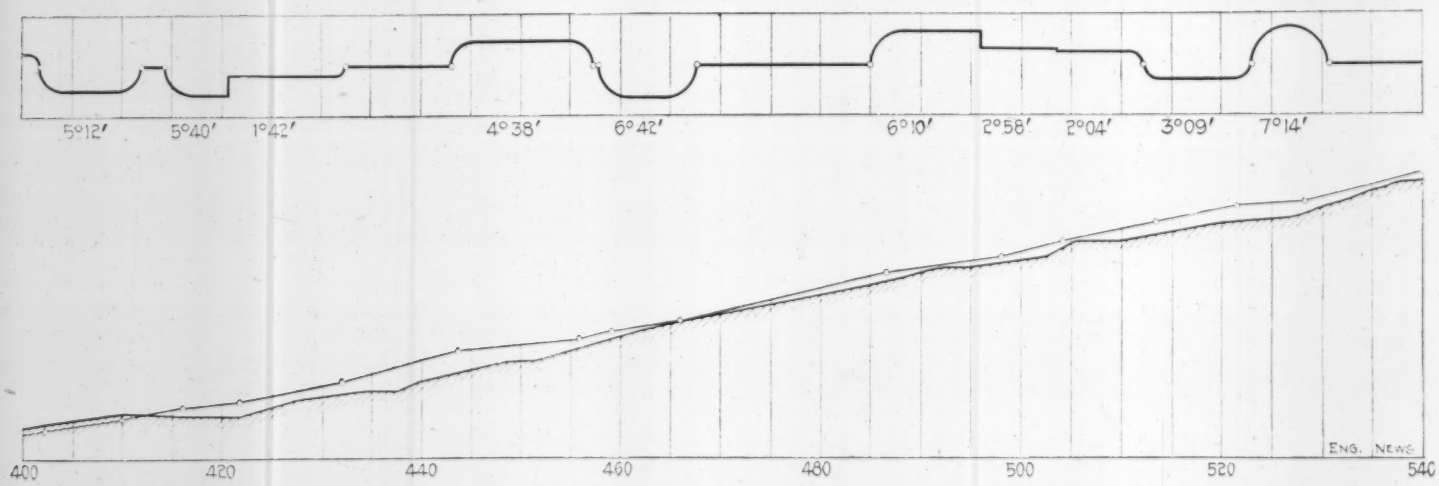
On single lines that are exclusively for freight, superelevation on ruling grades should be made for not over 15 mi. per hr. It is less expensive to slow down the descending movement than to reduce tonnage rating on account of excessive superelevation. This is specially true on curves of large central angle. As an example, two engines (one helping) hauling 3500 tons of coal ordinarily stalled on an 8½° curve with 185° central angle and 5½-in. elevation. The elevation was reduced to 3 in. and no difficulty was had. This curve was compensated 0.04% per degree and was on an 0.85% grade. On many mountain roads a long train may be on seven or eight curves at once, and when such is the case, observation of minor points are of great value when tonnage is the main issue.

SPIRAL OR TRANSITION CURVES

The object of the spiral curve is twofold: 1, to afford a run-off and a run-on from a level cross-section to a superelevated cross-section; 2, to ease the horizontal passage from a straight line to a curve.

It is evident that in passing from a level position to a superelevated position, when the inner rail of the curve is laid at grade, the center of gravity of the mass of the train must be raised through a distance equal to half the superelevation. This is generally a minor rise, but in order to haul uniform tonnage this minor point should be carefully observed, especially where limiting conditions are found, such as places near the end of a long-continued effort.

It has been proposed that the inner rail be depressed a distance equal to half of the superelevation, and the outer rail be raised the same amount. While this has been objected to, it can be done and so maintained, and from a tonnage haul standpoint it is desirable. The railway of the future, scientifically operated, will find conditions such as these limiting its tonnage unless care is taken. While it might be said that refinements in the track are unimportant, it should be borne in mind that, in order to realize the full value of improvements, these matters must be taken into consideration. A combination of correct conditions results in the most effective operation.



PROFILE OF ACTUAL GRADES AND PROPOSED CORRECTION WHICH WOULD ALLOW ABOUT 25% INCREASE IN TONNAGE RATING FOR SLOW FREIGHT TRAINS

REVERSE CURVES

Curves that reverse without any tangent between them mean operating expense. Not only must the superelevation change abruptly, but the trucks must change their position in the same manner. It is considered good practice to leave room between the points of spiral for four freight cars to straighten up after they change direction. On most new construction, provision is made for at least 1000 ft. between curves, and this practice is recommended unless great expense is involved.

THE EFFECT OF TRACK CONDITION

From a tonnage standpoint good track includes the following: (1) Mathematical alignment; (2) superelevation conforming to the speed; (3) an unyielding sub-grade; (4) rails heavy enough so that the depression under the ruling grade is small; (5) sufficient ties beneath the rail to transmit the load uniformly to the sub-grade; (6) ballast deep enough to secure good drainage and distribution of loading; (7) as much strength as is necessary.

On a branch line under construction, the work engine had difficulty at first in handling eight cars of ballast. During the ballasting, the surface was very bad, and the alignment

poor. As each section of the line became ballasted, the work engine was gradually able to haul more cars until it was finally able to haul 20. On the main line of the same division, where the same grade ruled the tonnage, this same engine could haul 25 of these cars. This represents the effect of improving line and surface. As the refinements of surface are gradually attained, the effect becomes noticeable at once in the speed of the tonnage trains, irrespective of hauling increased tonnage.

A mountain grade of 116 ft. to the mile (2.2%) and 12 miles long, was in bad shape, due to poor drainage and dirty ballast. It was determined to overhaul the grade, giving the ballast a thorough cleaning and repairing the drainage. After setting line and surface stakes, the engineers were accustomed to board the freight trains going up the grade on their way home at night, doing so with ease on account of the slow speed of the train. As the work progressed, and the track came to better line and surface, the speed of these trains so improved that the engineers had to slow them down to get aboard, until this procedure was stopped by the superintendent. As the power of a locomotive can be translated into either tonnage or speed, the effect of the better surface of the track can readily be seen.

EFFECT OF TUNNELS

Many railroads are suffering today on account of the fact that during the early days of construction it was not thoroughly realized that a tunnel might be a limiting feature. The following are the causes of the limiting effect: (1) Darkness, making the engine crew less confident; (2) a derailment is almost sure to result in serious damage and loss; (3) the heat in long tunnels, especially if of small section; (4) the track conditions, such as line and surface, are never as good as on the outside; (5) the rail is generally damp, causing either the excessive use of sand, or the slipping of drivers; (6) drainage is usually bad and difficult to improve; (7) there are usually speed restrictions; (8) it was formerly the practice to carry maximum grades through tunnels in order to shorten them, and this serious defect in many cases makes tunnels the ruling points; (9) in tunnels of small section the use of helper engines is undesirable on account of the heat; (10) the smoke and gas add to discomfort of operation; (11) the impracticability of firing in long tunnels causes a drop in steam pressure.

There have been many plans devised for tunnel ventilation. Most of them are successful under some circumstances, but none is successful under all conditions. The Churchill system of ventilation, by which air is blown through the tunnel from one end through nozzles fitted at the sides of the tunnel, is successful if the enginemen operate the locomotive so that the smoke is blown ahead of the engine.

Double-track tunnels are of sufficient section so that there is little discomfort in a tunnel a mile long, even if the locomotive is fired all the way through. The practice in Europe has always been much better in that even with single-track tunnels their section has been large enough so that they are less uncomfortable than those in this country. Tunnel ventilation in Europe is largely restricted to the dilution of locomotive gas with plenty of fresh air, rather than driving the smoke and gas ahead of the engine.

In the construction of new tunnels, an effort should always be made to reduce the grade in the tunnel considerably below the ruling grade, so that there may be no need of touching the fire during the passage through the tunnel. Ample section to secure good conditions is essential. In this connection it should be noted that the effect of long single-track tunnels of narrow section on the ruling grade is to reduce the tonnage rating in the tunnel by 10% at least.

EFFECT OF LENGTH OF GRADE

The effect of the length of a ruling grade depends entirely on what speed it is necessary to make up that grade. Hardly any operating division has more than 40% of ruling grade in either direction. It is generally computed that a train must average 10 mi. per hr. over a division of 100 miles in order to secure the best economy. Assume a division with 40 miles of ruling grade, and 60 miles of either downhill or less than ruling grade. If 8 m.p.h. is averaged on the ruling grades, and 12 m.p.h. on the down grades and less than ruling grades, the run may be made in 10 hr. If a grade is very short, following a stretch of either downhill or less than ruling grade, sufficient speed may be had at the bottom to carry the train over the top, even though the ascending grade be considerably more than the ruling grade. As the train goes up the hill, its speed will constantly decrease. The speed at the top of the hill must be such that the engine still has some margin between its maximum tractive effort and what is required of it. This result depends entirely on the speed of the train at the foot of the grade.

Such a grade is called a "momentum grade," and it is probable that there is not an important railroad in the country but what has portions of the line operated in that manner, even though the officers do not know it. Were it not for momentum, it is likely that many curves would prove to be stalling points that are now passed around with little (if any) trouble. We are learning more every day about handling trains and power at low speeds, but it must be understood that these low speeds are only for use for short periods of time, and not for general practice over a whole run.

When the grade is long enough for the train to become stretched out fully upon it, or, in other words, when the engine settles down to a constant speed with its maximum tonnage, the rating speed for that particular train becomes fixed. Without a rise in the steam pressure, the train cannot accelerate as long as the grade remains the same. If there is a large percentage of this character of line on the division, the rating speed must be considerably higher than if there are only one or two such places. For instance, it may be possible to average 7 mi. per hr. over one piece of grade, if that is the only piece on the division, because the difference in time should be made up on the rest of the division. But it would be manifestly improper to load an engine so that such a low speed would be made over the whole run. Not only on account of the low speed, but the constant demand on the engine would be such that the fireman would play out, and a failure would be the result.

ADHESION TO RAIL

An engine cannot do work and overcome train resistance unless it can transmit its cylinder work to the rail by means of adhesion due to the weight of the engine and the friction between wheel and rail. The adhesion may be reduced by a number of conditions as follows: (1) Moisture acting as a lubricator; (2) frost; (3) grease; (4) poor rail surface; (5) manganese or other metals in the steel; (6) excessive superelevation, throwing too much weight on one side; (7) inability to use sand (as shown on a curve the sand does not flow well upon the rail). Poor rail surface may be due to poor subgrade, worn rails or insufficient maintenance work. Driving wheels slip more readily on manganese-steel (as in crossing frogs) than on ordinary rails, as the coefficient of friction is reduced.

PROPER PERCENTAGE OF RATING

A locomotive standing on a dry steel rail should be capable of exerting a pull on a spring balance equal to (approximately) 25% its weight on drivers. This amount can be increased by the application of some medium to increase the coefficient of friction, such as sand, to about 35% (for momentary purposes only). This same pulling power can be used to haul a train, including, of course, the engine and the tender itself.

Ratings in use are never as great as could be pulled by the locomotive utilizing a tractive power of 25% the weight on drivers. The reason is apparent. Time is the essence of rating. The governing question is: For how long a time must the locomotive be required to exert its maximum pull during any particular run? If it is required to exert a maximum effort for only about five minutes at a time, the rating might be established for a maximum effort, provided that time for rest of man and recuperation of fire elapses between the periods of maximum effort.

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The Placing of Monuments in Relation to City Planning is discussed in an article entitled "The Decoration and Furnishing of the City—Statuary," in "The Town Planning Review," for February, 1913 (University of Liverpool, England). We quote a paragraph from the article, which is by S. D. Adshead, as follows:

The successful placing of monuments, and especially of the smaller ones, calls for a sense of appropriateness, possessed only by the artist. The most important of all monuments is that which commemorates an epoch-making event which is of national and of common interest, and which is erected to keep alive in the bosom of the nation a crisis from the throes of which it has successfully emerged. Arcs de Triomphe, Washington Obelisks, Statues of Liberty, Crimean monuments, and others stand for such events. These should be erected on the most crowded of public sites. Then there are the monuments which are erected to the memory of statesmen, philanthropists and kings. Here is the greatest need for discretion, for it is not all men who can be counted worthy of being petrified in stone, and if their statues are really to beautify our thoroughfares, we must needs dress up or pose John Smith out of all recognition. Everyone must admit the difficulties of metamorphosing the plain man into a beautiful form. With a Henry Irving, a state official or a soldier, it is possible, but not so in the case of the plain man. Better would it be to resort to the medallion or the bust on a column; the first duty of the erector of monuments is to beautify the town. But there is another kind of sculpture—that which is allegorical. This is best placed amidst trees and fountains and Nature's retreats; it is essentially the sculpture for the park.

A Reinforced-Concrete Beacon Tower, Alexandria, Egypt

The entrance to the outer harbor at Alexandria, Egypt, is protected by a beacon tower located one and a half miles from the nearest coast line and about three and one-half miles from the port itself. In 1907 a new tower was placed at this location, consisting of steel struts reaching down into the ocean bottom and carrying at their top a steel-frame work which held the gas tank and the light. In a severe storm Feb. 10-11, 1911, this tower was completely destroyed and the main part of its framing was afterward found nearly two miles away. The harbor has a very large use, over 4000 steam vessels entering it every year, and at the same time it is located in a zone where severe storms are quite frequent. It was, therefore, necessary to replace the steel beacon as soon as possible, and at the same time to replace it with a structure capable of withstanding the shock of waves and wind.

The four types of beacon considered were, first, a steel-frame work similar to the old one; second, a solid masonry lighthouse structure; third, a similar structure of concrete block made on shore, and, fourth, a reinforced-concrete structure, the main part of which was to consist of a hollow caisson cast on shore, floated to its proper location, and sunk on prepared foundations, after which it would be filled with concrete to form a solid masonry structure. On account of the solidity of the bottom and the impracticability of driving the steel piles very deep into it, the first type was not considered. The solid masonry types, while being of a certain stability, yet would require so much time in construction and a construction so apt to be disturbed by the prevailing winds and waves, that they, too, were discarded. This left the fourth type, which was designed and which now is in place.

The structure as designed and built is shown in detail in Fig. 1. It consists, first, of a seven-sided base in the shape of a frustum of a pyramid made as a hollow reinforced-concrete box and floated out to its location and sunk into place by filling it with concrete. This is surmounted with an eight-sided hollow reinforced-concrete tower which contains the gas tanks and which carries the light on its summit. The base was shaped as shown and placed to properly resist the prevailing winds and waves. The lengths of its main axes are 41.1 and 37.8 ft.; the thickness of the base, 8 in. This base is further reinforced with five transverse beams, each 8x16 in. and one longitudinal beam 12x24 in. The total height of this base section is 46 ft. It slopes up as shown, with an outer shell made up of reinforced concrete 6 in. thick, and braced with a central 12x12 in. column, from which radiate 8x8-in. bracing beams. All sections are reinforced, though this reinforcement is not shown on the drawings. The tower is 36 ft. high and is designed as shown in the figure. It is 12.3 ft. in diameter at this base and 8.2 ft. at its summit. The thickness of the walls is 4 in. and the beams which brace these walls 6x6 and 8x8 in. In addition to the beams there are transverse floors which serve to brace the structure and to hold the gas tanks.

This whole structure weighs about 1700 tons, which, after substracting the loss of weight under water, makes a total pressure on the base of about 1100 tons. There was no exact method of figuring the pressure of the waves upon it, but the designers considered that such a weight was sufficient to withstand the worst storm possible at this location. The reinforced concrete was figured according to the French ministerial instructions, except that the walls were made somewhat thicker and the steel

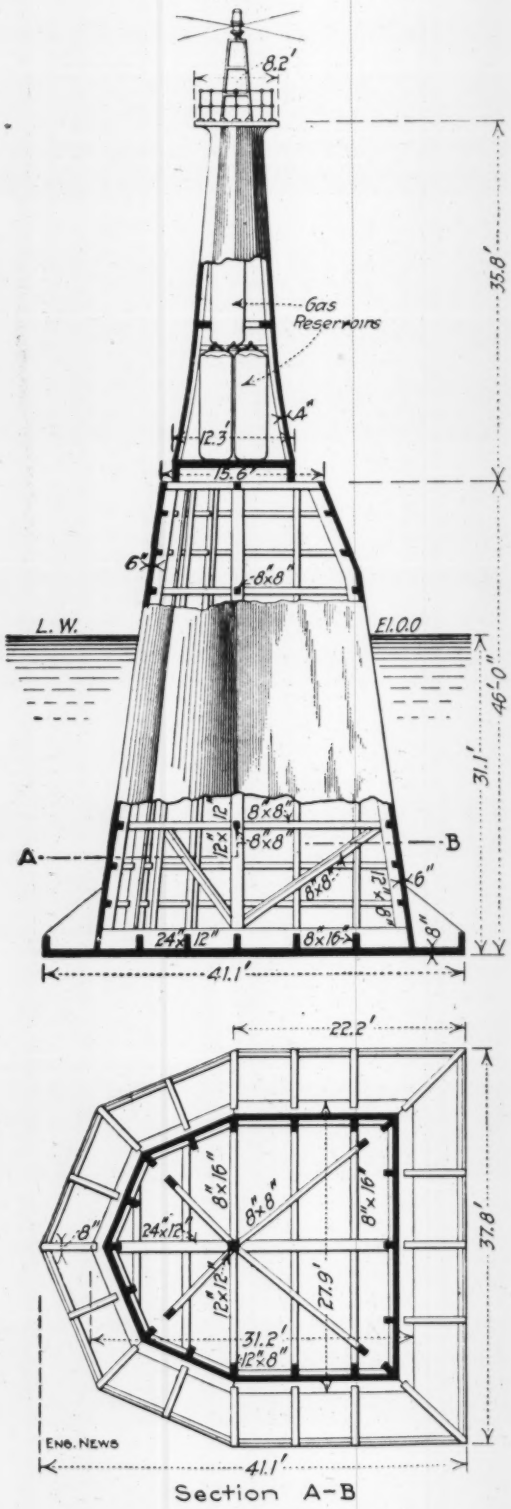

FIG. 1. DETAILS OF CONCRETE BEACON TOWER, ALEXANDRIA, EGYPT, HARBOR
(Reinforcement not shown)

somewhat larger on account of the possible attack of the salt of sea water. A 1:2:4 concrete was used for the reinforced-concrete work, and great care was used in placing it. No other waterproofing precautions were taken.

The base caisson was made on shore in two parts. The

lower 24 ft. of the caisson was cast in place on a launching platform on shore, and after it had reached a sufficient set was launched off the platform into the water, as shown in Figs. 2-4. This caisson was floated to alongside of a wharf and the remaining 11 ft. cast, carrying the structure to the floor on which the tower portion rests. At the same time, at another place on shore, the tower structure was cast in place and lifted by a heavy derrick onto a barge, which was floated alongside of the base.

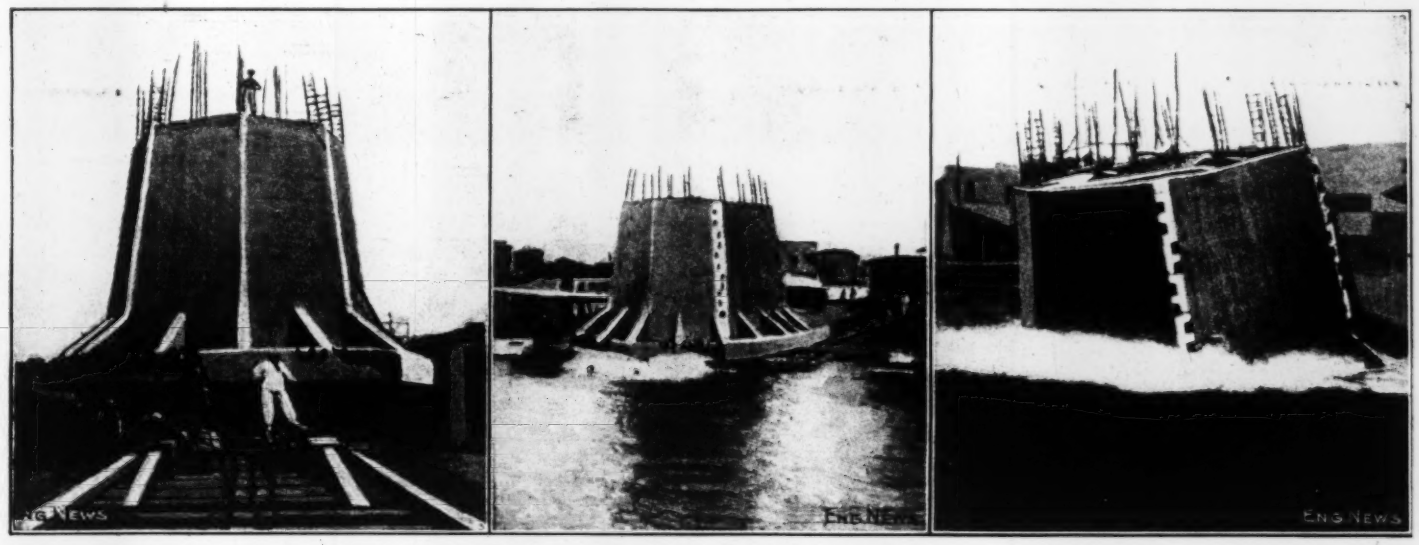

FIG. 2. CAISSON IN LAUNCHING STAGE FIG. 3. JUST ENTERING WATER FIG. 4. IN WATER

FIGS. 2-4. PROGRESS IN LAUNCHING LOWER CAISSON OF BEACON

It was the original intention to place this tower portion upon the base and to float the two together to the proper location of the beacon in the far harbor. Operations toward this end were successfully started. The tower was placed on the base and securely fixed thereto with interior timber struts and connections. Lines were then passed around the top of the tower, the top of the base, and the bottom of the base, and these lines carried to the outer gunwales of two sea-going barges which were lashed together on either side of the structure. Tugboats were then attached to the outside of these barges, and the towing commenced. The lines to the structure, which are shown in Fig. 5, were provided with tackle so that the tower could be moved one way or the other to keep it vertical.

This towing was started on July 6, 1911, and the distance of about a mile and a half from the place of manufacture to the breakwater of the port was successfully completed. From this point to the location of the beacon was in open sea, subjected to severe winds, and the second part of the journey was postponed from the 6th of July to the 1st of August, awaiting favorable weather conditions. On the 1st of August it was thought that these conditions were favorable, and the towing toward the proper location, some 2¾ miles farther on, was started. Owing to a certain anxiety on the part of those in charge, and also to a slight, though not great, swell in the sea, the tower became loose from its cables and toppled over on one of the towing barges. This accident seriously delayed the work. The tower was not so damaged that it could not be used again, but it was considered inadvisable to attempt to use it in the fashion in which it was originally designed. It was, therefore, removed from the lower structure and brought back to Alexandria, where it has since been set up as a beacon light on one of the piers there. The base of the structure was somewhat injured by the upper part falling on it, but not so seriously but what it could be repaired in the course of two or three days. The towing of this base caisson was then continued, without incident, to the proper location.

This location had been dredged level and somewhat lower than the surrounding sea bottom. The caisson base was brought above the level portion and pumped full of water until it sank to a good bed. When it had been sunk, concrete was placed in the water-filled box for a depth of some 20 ft., the process being continuous so as to prevent the formation of laitance planes. The remaining water was then pumped out of the caisson and the rest of it filled with concrete laid in the open. At the same time the extra chains and iron which were used in connection with the work were dumped into the outside boxes formed by the extension of the base beyond the outside of the walls of the caissons.

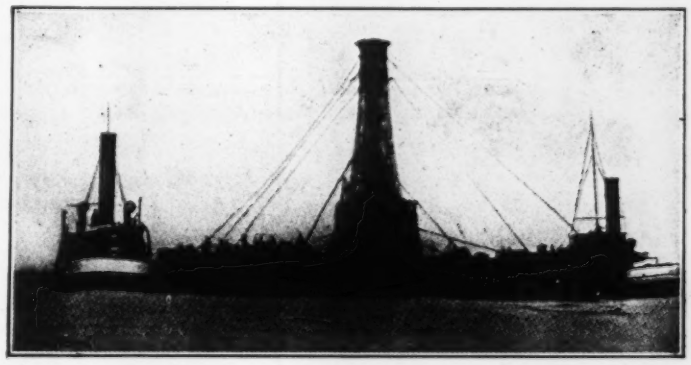

FIG. 5. TOWING CAISSON AND TOWER IN HARBOR

A construction plant was then set up at the barges and a framework erected on the base which now had a solid footing on the ocean bottom. Inside of this framework the reinforced-concrete tower was erected. The work was completed without any very great difficulty, although the weather was at times so heavy that it would have been impossible to have carried on any very great amount of work if a solid masonry structure had been decided upon. The falsework was removed and the structural part completed on Oct. 1, and on Nov. 10, 1911, the beacon was

t alight for the first time. This meant a period of six months from the beginning of the work until its completion, two months of which were delays due to impossibility of getting material and unexpected accidents connected with the work.

During a severe storm on Dec. 23, 1911, a 4,000-ton steamer lost its course in getting into the harbor, and was thrown against the beacon light. Under the combined effort of the very violent storm and the shock of the ship, the tower was slightly displaced and was given an inclination of about 1°. It, however, suffered no structural damage and the light was not put out. This severe test has proved that the structure is able to withstand a very severe usage.

The light was designed and built by the Corps de Ponts et Chaussées, of France. Its construction and design is described in *Annales des Ponts et Chaussées*, 1912–VI–November-December.

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An Unusual Design for Paving a Street Intersection

By S. Cameron Corson*

In the year 1911 a franchise was granted by the Borough of Norristown, Pa., to the Norristown Transit Co., a branch of the Philadelphia & Western Electric Ry. Co., to occupy Airy and Markley Sts. In return for this privilege a certain amount of paving was required to be done by the company, including the intersection of Markley and Airy Sts.

These streets are 66 ft. wide over all and 36 ft. wide between curb lines. On Airy St. there is a viaduct which passes over Markley St., the adjoining tracks of the Philadelphia & Reading Ry. Co. and Stony Creek. The roadway of this viaduct is about 25 ft. wide, beyond which there are sidewalks, each 9 ft. wide. The balance of the total width of Airy St., or 24 ft., is divided into two 12-ft. roadways, but the real street intersection is entirely clear.

The track of the Norristown Transit Co. is laid on and along a curved right of way with a radius of 120 ft. on the center line. All of this area, including a sidewalk 9 ft. wide on the east end to 15 ft. wide on the north end of the curve, was purchased by the company and formally dedicated to and accepted by the borough for public use.

The traffic at this intersection is very heavy in every direction.

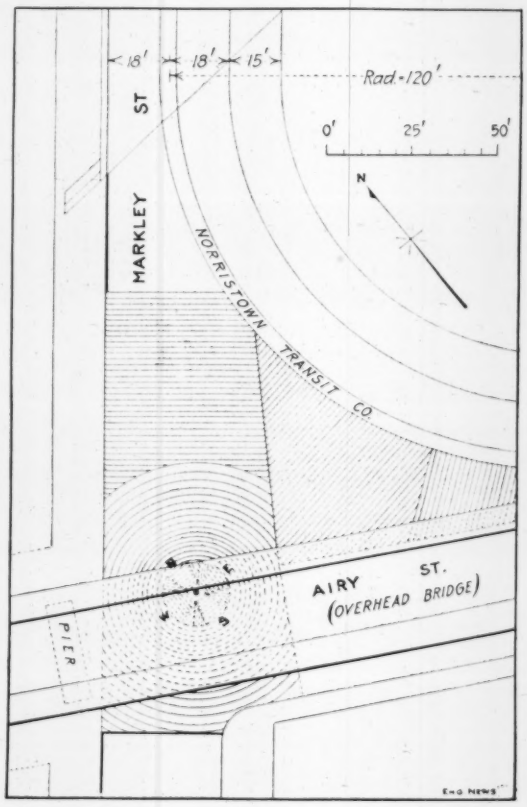
Ordinary methods of meeting these traffic conditions did not meet all of our requirements, so we decided to put in a circular intersection, as shown by the sketch, which was suggested by my assistant, Harry P. Hiltner.

The sewer manhole lid was used as a center and blocks were laid on radial lines set on the four points of the compass. The interior of the inner circle, which has a radius of 10 ft., was made to represent a maltese cross, and on the extremities of each wing of the cross and on the meridian lines we placed four buff-colored blocks, one at each point to indicate the points of the compass.

Each radius was increased by the thickness of the blocks until it had covered that portion of the intersection that it was desired should have the transverse lines to the general traffic. The extreme outside radius was about 40 ft.

This work was done at no extra cost to the railway company; in fact, the engineer in charge informed me that there was less loss for cutting and breaking than he had had in a much smaller street intersection.

Outside of the 10-ft. radius the blocks were laid whole, which was an especial advantage for the reason that in the lines of traffic there would not be the usual small



Street-Intersection Paving Plan, Airy and Markley Streets, Norristown, Penn.

pieces of blocks used to piece out on the lines of the ordinary gussets.

The only difficulty encountered in this construction was on the circumference of the circles as they gradually increased in length. The difficulty was to break joints This was overcome, after several trials, by inserting a block of two-thirds length at regular intervals.

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A New Design of Underfeed Stoker for steam boilers is being put out by the Sanford Riley Stoker Co., of Worcester, Mass. The coal is forced by a plunger from a hopper through large passages in reciprocating grate bars having inclined (20°) upper surfaces. A grate and its corresponding coal piston are moved together by parallel connections to a crank on a jack shaft. The cranks for adjacent grates are set 180° apart so that each grate slides past its neighbor. The lower ends of the reciprocating grates are built as pusher noses to force the ashes to the bridge wall over lapping auron plates, which hang down at the ends of a rack. The ashes thus pass through an opening which can be adjusted by changing the position of the rack.

A blower for each furnace is chain driven from the stoker jack shaft and discharges into a chamber whose roof is formed by the inclined grate bars and whose bottom is a roof to the ash pit. The ratio of air to coal fed remains constant unless the blower sprockets are changed. It is claimed that this results in better combustion. It is also claimed that the repeated shearing of the fuel bed by the moving grates prevents accumulations of clinker and that ash chunks are crushed by the grate noses.

*Borough Engineer, Norristown, Penn.

EDITORIALS

Co-operation between Engineering Schools

A few years ago a project for consolidating the Massachusetts Institute of Technology with Harvard University was actively discussed; but opposition of the alumni of the Institute caused its abandonment. Since then the advocates of the union of these institutes have talked of a more or less close coöperation, in view of the impending removal of Massachusetts Institute to Cambridge. Just what sort of coöperation may perhaps develop, is disclosed in the recent annual report of President MacLaurin. He lays down the following three propositions:

(1) No extensive coöperation can be maintained with any satisfaction to either party and consequently with any chance of permanence unless the idea of competition between the institutions is eliminated. (2) The scheme to be worth much consideration must be broad enough to throw open the resources of both institutions (in equipment and in teachers) to at least some of the students of the other. (3) The obvious way to coöperate is in the treatment of the graduate students, leaving the greater part of Technology entirely alone.

President MacLaurin calls attention to the fact that duplication of effort in two neighboring institutions is not always regrettable, provided the men and plants involved are employed to their full capacity. The unit cost of educating young engineers does not follow the same laws which govern the production of machine screws in a shop. It is accepted that the efficient unit of education, if we may for the moment regard individuals thus impersonally, increases with subdivision and duplication of the classes after a certain point is reached, and this point, is doubtless attained long before institutions grow to the size of Harvard and Technology.

President MacLaurin in this report points out a few of the ways in which coöperation would be advantageous, and instances ways in which one institution or the other, if furnished with duplicate equipment, would not utilize it to complete advantage. For example, it would cost Harvard hundreds of thousands of dollars to duplicate the complete mining and metallurgical laboratories which the Institute is planning to erect, and all the students in mining and metallurgy at Harvard could easily be accommodated in the Institute's new laboratories without detriment to the latter's students. On the other hand, the Institute could not possibly duplicate the Harvard University Museum with its enormous collection of minerals, fossils, etc., which might well be open to senior students of the Institute without interfering with the work of the Harvard students. The Institute contemplates a large development of its department of naval architecture and the building of a model basin, costing upwards of $100,000. This could be used by Harvard students as well. The same rule applies to certain eminent teachers. Recently the Institute lost a highly esteemed professor of geology by the transfer of his work to Harvard where his classes are not so crowded but that students of both institutions could be effectively dealt with by a man of his capacity. A similar condition exists in the case of this professor's successor at Massachusetts Institute, as it appears that the two men have earned their reputations in different branches of the same broad subject, so that their courses need not conflict.

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Legislation to Avoid Railway Strikes

The Railway Business Association has issued a letter urging Congress at the coming extra session to undertake the enactment of a law for the better avoidance of railway strikes. The Erdman law, under which arbitration is now in progress between the railways east of Chicago and the locomotive firemen, is admittedly defective in many respects. Entire responsibility for the decision of the case is placed in the hands of a single arbitrator. The other two arbitrators, for which the act provides, are chosen by the respective parties to the dispute, and cannot be counted on for unprejudiced action. Again, the time fixed by the act for the investigation and taking testimony by the arbitrators is insufficient. In the present arbitration of the firmen's case it has been necessary, by agreement of both sides, to extend the time for presentation of testimony. The Erdman act applies only to employees engaged in train service. Other classes of railway employees, however, are equally necessary to railway operation, and means should be provided by which disputes concerning their conditions of employment, many of which have been of a very serious nature during the past dozen years, can be submitted to arbitration.

In order to bring the Erdman act into operation, also, one of the parties to the dispute must make a request for arbitration. In case both parties to a dispute assume a stubborn attitude, there is no one authorized to come forward representing the public interests and urge upon them an agreement for arbitration. It is, moreover, uncertain what effect the act creating the new Department of Labor will have upon the Erdman act. Section 8 of the Department of Labor act empowers the Secretary of Labor "to act as a mediator and to appoint commissioners of conciliation in labor disputes whenever, in his judgment, the interest of industrial peace may require it to be done." If this clause is given a broad construction, it would appear that the Secretary may intervene in any industrial dispute whatever and use his good offices for the establishment of an arbitration agreement, as has been done in the recent labor disputes between the railways and the engineers and the railways and the firemen by Commissioner Neill, of the Department of Labor, and Judge Knapp, of the Commerce Court. It may be considered a step in advance to have a Cabinet officer definitely charged with the duty of conciliation in labor disputes; but this is only a single step in advance.

It is doubtful if there is a single measure now appealing for action by Congress which has so important a relation to public welfare as the provision of a better law for the avoidance of railway strikes. Just at the pres-

ent time the country is witnessing a demonstration, in the flood-stricken cities of Ohio and Indiana, of the dire results which follow even a partial interruption of railway traffic for a few brief days. The widespread calamity which has befallen a dozen cities in the Ohio River valley, is a trifle in its disastrous effect in comparison with what would result from such a widespread annihilation of railway transportation as might at any time be caused by a general railroad strike. The Railway Business Association will render a valuable public service if it can arouse public sentiment to the extent of inducing Congress to deal with this important matter.

A Unique Explanation of the Chemistry of Combustion

The proceedings before the Arbitration Commission which is taking testimony in the dispute as to wages and conditions of service between the railways east of Chicago and the Brotherhood of Locomotive Firemen were enlivened last week by the testimony of Frank Kelley, a fireman on the Cumberland division of the Baltimore & Ohio. Mr. Kelley is no friend of the mechanical stoker, and declared that by hand firing he could decrease the coal consumption of a locomotive 50 per cent. over the amount used by a mechanical stoker. His explanation of the process of combustion is given as follows in *The New York Times* of Apr. 3:

> The chemical reactions, you understand, that take place in a firebox are entirely different on a stoker engine than what they are on a hand-shoveled engine. Science tells us that 75 per cent. of the air we breathe is oxygen, while a very small portion of it is hydrogen. Oxygen itself is an aid to combustion only, while hydrogen will burn with an intense heat. The presence of the hydrogen gas burning can be noted by extremely white, bright flames in the firebox.
>
> Now, then, I have found this to be my actual experience, that while on the line of road, after we get a little fire built up with a shovel and wet our coal, and when we have got the engine to working, the temperature of the firebox is something over 110 degrees Fahrenheit. That is naturally pressure enough to separate the oxygen from the hydrogen, and consequently by wetting the coal we get what is known as H_2O, two atoms of hydrogen and one atom of oxygen in the make-up of a molecule of water, and by freely distributing the water over the coal, we get the hydrogen that is necessary to burn, and we also get a little more in addition to the elements that are taken out of the atmosphere to add to our oxygen, and it will be much more aid to the combustion of any foreign or volatile substance that might arise in the coal, consequently we do not have the amount of clinkers to put up with, we are getting a freer draught through the grates and on the other hand we do not have to be inhaling dust from one end of the division to the other.
>
> I was only looking for an opportunity of this sort, Mr. Lee, where I could get up and put myself in evidence that if the stoker people or the stoker inventors would question our rights in regard to a man's amount of wages for a man's amount of work, I would place myself in evidence as going to the Grand Lodge and getting them to coöperate with the various anti-tuberculosis societies of the different states, if the stoker was allowed to remain in vogue, and have them abolished.

One is more or less used to seeing such amusing pseudo-science spread abroad in the newspapers, but it has a very serious side. This is part of the testimony in a case involving an annual expenditure of several million dollars which the public, in the long run, will have to pay. It does not require any great stretch of the imagination to see bills introduced in state legislatures and enacted into laws forbidding the use of mechanical stokers on locomotives. Such legislation against the use of labor-saving machinery means, in the long run, a further increase in the cost of living.

The Need for Scientific River Regulation; the Opportunity of the Engineering Profession

The terrible destruction of life and property by the floods of last week, covering a broad stretch of densely populated territory from Indiana and Illinois on the west to Vermont and New Hampshire at the east, has aroused the public as it has never been aroused before to the need of taking some measures to minimize such flood destruction. As to what can be done, what measures are feasible and what are not, the public and even a large part of the engineering profession are wholly at sea.

The papers are filled with vague talk concerning forestation, levees, reservoir construction, outlets, auxiliary channels. All sorts of nostrums are put forward. Mr. Riker, of Brooklyn, for example, declared in a published letter last week that the storm which produced the destructive floods was caused by the cold polar current, which swats the Gulf Stream amidships and crowds its beneficent influence away from the United States! Mr. Riker would prevent such storms and floods, therefore, by building a dam in the ocean across the Banks of Newfoundland in water some 200 to 300 ft. deep.

There is danger that as a result of all this mass of crude theory and pseudo-science the public may be led to undertake some wild and foolish expenditure. Millions and tens of millions may be wasted on some crudely planned scheme. The money for it would be raised, of course, by an issue of bonds, the payment of which would be conveniently shoved off onto a future generation.

The other danger, and probably the greater one, is that the aroused public demand for something to better present conditions and to safeguard against similar future destruction may be allowed to spend itself in useless frothy talk for lack of intelligent guidance. Here, it seems to us, lies the opportunity for the engineering profession, or at least for its wiser and abler members, to render a great public service and at the same time give opportunity for the profitable employment of many competent engineers.

The situation is very well put by Mr. Julian Griggs in his valuable paper on the Columbus, Ohio, flood, which appears elsewhere in this issue.

Mr. Griggs says that a few engineers had realized, years ago, that effective means ought to be taken to enlarge the channel of the Scioto so as to protect the city against the dangers of enormously destructive floods; but these engineers had realized also that the great amount of money this work would require would prevent such a proposal receiving public approval until the people had been given an object lesson of the destruction which a flood could bring to their homes.

The object lesson has come to Columbus, and, in a form more or less severe, to fifty other cities. The engineering profession has now an opportunity to guide the public aright as to what measures should be taken to guard against such destruction.

Some of our older readers may recall that nearly a quarter of a century ago when the city of Johnstown, Penn., was wrecked by a flood brought down upon it by the failure of an insignificant dam, the American Society of Civil Engineers appointed a committee to investigate the disaster. That committee reported (and its report was given wide circulation) that the dam which

caused the destruction was built without competent engineering supervision and that no responsible engineer had charge of its maintenance.

Unfortunately, the committee went no further than to absolve the engineering profession from blame for the disaster. Had it gone further and taken the initiative in promoting legislation, as it might have done, the object lesson taught by the Johnstown disaster might have resulted in the establishment of systematic state supervision of dams and storage reservoirs in a number, at least, of the most important states; and a huge amount of waste and destruction which has resulted from dam failures in the past 25 years might have been avoided.

It seems to us that a similar great opportunity is now open to the engineering profession. The public is in a mood to welcome information from an authoritative source. It ought to be informed that the science of river regulation is not a vague mass of conflicting theory; but that it has been developed in Europe to an important and well established branch of engineering. Many years ago it came to be realized on the continent of Europe that in order to protect from frequent destruction the dense population on the river flood plains, means must be taken for the regulation and control of rivers great and small. Most important of all, it was realized that streams and rivers cannot safely be left for each riparian owner to do with as he pleases, or even for each city and town to deal with according to its own condition. In Germany, for example, there is a general organization dealing with the rivers as a whole, with power to prevent the obstruction of their beds or their flood plains in a way that may injure the general welfare.

Contrast with this the situation in the United States. Suppose a railway is to be built across a river bordered on each side by a broad flood plain. It is not uncommon to see the flood plain crossed by an embankment which will entirely cut off the flow of the water except through the river channel itself. In fact this is done so frequently that it hardly excites remark. If the river is navigable, some officer of the Corps of Engineers may be responsible to see that the passage of boats up and down the stream is not unduly obstructed by the bridge, but there is no authority whatever, State or National, which has the responsibility for preventing improper obstructions being placed across a river's flood plain.

In some cases, indeed, the engineer of the railway company, or of the municipality, in case the bridge is built by a city, may have the foresight and wisdom to urge provision not merely for the ordinary flood flow in the main channel but for such extraordinary flood flows as may be expected to come once in a quarter or half a century. In nine cases out of ten, however, we venture to say that if such provision for extreme floods causes an increase in expense, the engineer will be overruled by the so called practical business men who are in authority over him. This is to be expected, and will continue until the time when the Federal government or the individual States perceive the necessity of putting under government control the whole matter of river regulation.

It is a pretty safe conjecture that in most of the cities which suffered flood damage during the last week of March, it will be found on investigation that there had been gradual encroachment upon the river channel in the city, such encroachments tending, of course, to raise the flood levels where they occur. This was so in Columbus, as shown by Mr. Griggs' article elsewhere in this issue. In Dayton, which suffered so severely, the need of enlarging and straightening the channel of the Miami River through the city had already been realized. Only five days before the flood came, a letter reached us from a city official informing us that plans for this work had been prepared and were to be carried out this summer. In the floods which ten years ago caused enormous loss in Kansas City, one contributing cause was the encroachment upon the river channel.

These encroachments proceed from causes entirely natural. Real estate in the center of a city becomes very valuable. Each riparian owner on the bank of a stream desires to add to the area of his property by filling in along his water front. When one property owner does this, others are not slow to follow his example. The City Engineer, if the city is progressive enough to have such an official, may possibly protest and call attention to the danger of such encroachments; but his voice is like that of one crying in the wilderness. What is the influence of one engineer compared with that of a dozen or a hundred wealthy property owners?

A most notable example of the strong influences which operate to produce encroachments upon river channels is furnished at New York City, where for half a dozen years the city authorities, backed by a vast array of political influence and even by high technical authority, have been seeking permission to build piers farther out into the Hudson River, and thus narrow further the width of the city's great commercial artery. Fortunately, in these navigable waters, Federal authority has stepped in and prevented the city from the shortsighted attempt to injure its own welfare. The officers of the Corps of Engineers have stood like a rock against the propositions to further encroach upon the channel of the Hudson.

Had there been established thirty or forty years ago, State and Federal systems of river regulation under the direction of competent engineers, with authority to prevent encroachment upon river channels, a vast amount of destruction of property and life wrought by floods might have been saved. Because it was not done a quarter of a century ago is no reason why it should not be done now.

We should like to emphasize, however, that if such work as this is to be carried out successfully, it must be placed in the hands of engineers with the requisite ability, and they must be furnished with enough money and given enough independent authority and tenure of position so that they can create an engineering organization able to do things.

As we have before pointed out in these columns, every State in the Union needs a high-class engineering department organized on a permanent basis, free from political control, and with authority to protect the public welfare in all matters relating to the use of water, drainage, irrigation, power development, navigation, flood prevention and maintenance of low-water flow. Such a department might also undertake very properly the supervision of highway construction where state funds are applied to this work and the inspection of highway bridges, built and to be built, to see that public safety is secured and honest methods of construction are followed.

The public does not realize that for the lack of such intelligent, competent engineering direction to protect the interests of the public, many millions of dollars are

annually lost. Instances of this could be multiplied without number. In Florida, for example, recent newspaper reports before us state that the East Coast Canal, which was built under a land grant by a private company a few years ago, is now practically impassable. It is further stated that of 21,000,000 acres of land which the State of Florida was to sell for drainage purposes, but 1,000,000 acres still remain in the state's possession, the other 20,000,000 acres having been deeded away in a reckless manner with very little in the way of actual drainage effected to show for it. Our readers will recall, also, that the State of Florida undertook a few years ago to carry out drainage works on a large scale in the southern part of the state but without any adequate engineering investigation beforehand as to methods, plans, and costs and with results which are grievously disappointing.

In the far Western states a dozen years ago a great opportunity for profitable development was afforded by the passage of the Carey act, under which the Federal government agreed to turn over to the arid states certain areas of public lands which the states could improve by irrigation. Had any of these states been wise enough to establish a first-class engineering department with authority to supervise irrigation and to see to it that the plans made for works to be carried out under this law were sound and well matured, the act might have been made of the greatest benefit; and numerous prosperous and successful irrigation projects might have been established. But with the single exception of Wyoming the opportunity was wholly neglected. Land made available under the act was in many cases turned over to private promoters to speculate with as they pleased, with practically nothing in the way of effective and competent engineering supervision on the part of the state. The result is that with few exceptions, the project for developing irrigation under state control which the Carey act made possible has proved a dismal failure.

We need not take further space, however, to set forth the many ways in which the lack of efficient engineering control under governmental authority is involving the country in enormous waste and loss. The lack is due, we believe, to the fact that the public does not understand what a competent engineer can accomplish; and it is not willing to pay the price of competent engineering because it does not realize what valuable benefits such work can produce.

The public needs to learn that the engineer is not merely a man who squints through a transit or who draws lines on paper which, to the average layman, are absolutely meaningless. It is the province of the engineering profession, as long ago defined, to harness the great powers of Nature for the service of man. Equally is it its province to harness these great powers so that they shall not compass destruction.

We do not by any means suggest that the engineer should come forward at this time, like the quack physician in the midst of an epidemic, with the declaration that he can offer a cure-all for the evils that beset us. We do believe that the engineering profession, through its representative organizations should take means to inform the public as to what engineers can accomplish and as to the benefits which the public may gain by establishing competent and permanent engineering organizations for conserving the public welfare.

LETTERS TO THE EDITOR

The Need for Systematic River Regulation Work by the Government

Sir—The floods in the Ohio River valley and in New York, with their great destruction of life and property, once more forcibly call attention to the increasing necessity of controlling our river systems by suitable regulation. Most people still believe that such disasters are unpreventable and must be duly paid for, as in the case of war, by sacrificing many lives and large amounts of money. It seems to be unknown to them that river floods can be controlled, and that means of doing this are well known to engineers posted in this branch of their profession.

There are few directions where our national revenues could be spent on public works to better advantage than in river correction for protection against floods. Eleven years ago at the annual convention of the American Society of Civil Engineers, in Washington, D. C., I called attention to this subject and pointed out means and ways by which a beginning might be made in this important branch of engineering.

Western Europe is far ahead of us in this matter. While flood disasters in that part of the world are not impossible, yet their magnitude and the frequency of occurrence, where they occur at all, are now, or will soon be, so reduced, that the permanent investments for protection works are many times repaid.

Our streams are still to a large degree running wild in their original state. We have changed the face of the land by deforestation, by agriculture and by inhabitation; but we have not changed the rivers to correspond with the different rainfall runoff from these altered surface conditions. A larger proportion of rainwater now at once runs off from the more open and less retentive surfaces and thereby increases the flood volume of the streams. The denuded areas also allow more silt to be washed into the streams, which, by deposit in many instances, has tended to raise their beds and banks. These two changed conditions produce correspondingly somewhat quicker and higher floods.

The regulation of river channels to better the stream alinements and gradients, for the improvement of the adjoining land surfaces, is seen in Europe chiefly by the works along the Rhone, the Rhine and the Danube.

France and Switzerland, and particularly Germany and Austria, have been working on river regulation for over half a century and have become masters in the art of controlling and improving streams. The European engineers usually provide a fixed and suitable channel for the

river's ordinary flow, and an enlarged but also definite channel for the extreme flood flow. The exposed land of the latter channel is often cultivated to some extent, but yields a lower rental because the crops are occasionally lost by floods. Permanent bridges, roads, locks and harbors are provided primarily for the flood conditions, but are made suitable as well for ordinary conditions.

I believe the United States is the only civilized nation which has no government department in charge of river regulation. The army engineers by law look after navigation interests alone. There is no single authority here, as there is in other countries, controlling the entire stream, and regulating its alinement, gradients and cross-sections from source to mouth, with reference either to its floods, to its ordinary flow, to any improper pollution, to any deposit of offensive matter or to any reduction of its cross-section by artificial obstructions.

Is it not time that our river systems and lakes should receive the same intelligent treatment by expert engineers that is given to the rivers of Western Europe? That the subject is intricate and difficult is only a further reason why its scientific study should be undertaken as soon as possible.

It has been said that the cost of extensive river regulation works would be too great for our new country. Before the work in each drainage basin can be undertaken economically, it is necessary first to have a central authority established, and secondly to give the river systems the required preliminary study, and to decide upon the principles which are to govern their regulation. The cost of doing this much towards starting the work of river regulation is certainly not too great. There is no reason why all of our rivers should not at least be systematically studied and why proper solutions of the problems should not be prepared for all of the important streams. Their gradual and economic regulation in accordance with the results of such studies could then be undertaken in the order of their importance, and as the funds therefor were made available by Congress.

RUDOLPH HERING.

170 Broadway, New York City, Apr. 1, 1913.

The Wellsville Bridge Failure

Sir—In your issue of Mar. 13, 1913, you have an article on the failure of a steel-truss highway bridge in Colorado, by W. H. Hubbard, Jr. It might be interesting to state that if even the top chord of that truss had a vertical web in addition to the two 6x4-in. angles, the method of putting on the reinforced-concrete floor slab is absolutely dangerous, and permanently injurious to any bridge.

If the contractor saw fit to begin the construction of the reinforced slab at one end and built it continuously to the other end of this or any other bridge, then the Inspector's duty was to see that there was a counterweight (either of sand or gravel which was to go into the construction, or other dead load) placed at the center and halfway between the center and the far end, sufficient to balance the oncoming load due to the continuous construction of the reinforced floor slab.

If this were not done the amount of distortion in practice generally exceeds double the amount for which it is figured. Why the distortion should be greater I cannot tell, but I do know it takes place in actual construction. In stating this I am not criticising anybody's design except my own, and in quoting this and standing behind such a statement I am simply quoting my own experience in the same kind of construction. In building the Kennerdell bridge across the Allegheny River in Venango County, Penn., where the construction of a reinforced-concrete slab was started at one end with the purpose of continuing it across the different spans to the other end, the bridge had to be actually counterweighted. There was not only a perceptible distortion, but I was called from Pittsburgh to go to the bridge site by the local engineer in charge (Emery C. Read, Franklin, Venango Co., Penn.), for fear of permanent damage being done to the structure. When I arrived at the bridge site I was simply amazed at the excessive distortion, and was fearful that the top chord had received a permanent buckle, which, fortunately, proved afterwards not to be the case.

This was a structure that was designed for a good deal heavier loading than is common in highway practice, yet here was dead-load, without any live-load, causing the greatest and most excessive distortion I had ever seen in any bridge. I can speak with some intelligence as I had been in the past a contractor and erector of bridges for fifteen years of my life, and have spent my life continuously since 1876 in bridge designing and construction.

Since the experience at Kennerdell I begin the construction of a reinforced-concrete slab at the extreme ends, the center and quarter points.

E. K. MORSE,

Commonwealth Bldg., Pittsburgh, Penn.

Mar. 14, 1913.

Sir—In your issue of Mar. 13, you describe and illustrate the collapse during erection of a low-truss Warren-girder bridge; and in the same issue you comment editorially on the necessity of properly bracketing the upper chord to the transverse-floor system.

An examination of the drawings does not reveal that this bracketing was done, and no lateral bracing of the floor system is indicated at all, which would be necessary to make the bracketing (no matter how well done) effective. Evidently the concrete floor slab was to take the place of the usual diagonals. It occurs to me that the upper chords during construction were acting as unsupported columns of length equal to the span of the bridge. If this is the case it would be well that you would point out the lesson to be learned from this failure—the necessity of bracing and holding the chords in line until the concrete has set.

D. J. MCLACHLAN.

Calgary, Alta., Mar. 18, 1913.

A College Course in Photo-Surveying

Sir—In an editorial on "Stereophotogrammetry" in your issue of Mar. 27, 1913, you state, "It is doubtful if any American engineering college gives actual practice in photo-surveying, etc."

I beg to advise that the theory and practice of photographic surveying has been a part of the civil engineering curriculum at Syracuse University for the past three

years. The course offered covers eight recitation periods and 60 hours in the field and drafting room. Squads of five men each take about fifteen photographs which they develop and print. Contour maps, plotted from these prints or the negatives, are required from each student.

LOUIS MITCHELL,
Assistant Professor of Civil Engineering.
L. C. Smith College of Applied Science,
Syracuse University, Apr. 2, 1913.

Tornado and Flood Damage at Terre Haute, Ind.

Sir—In accordance with your request, Prof. McCormick and I went over the track of the tornado which passed through the southern portion of Terre Haute, Sunday night, Mar. 23. The first serious damage near the city was to the farm buildings and surrounding grove of trees owned by W. P. Ijams, the owner of Axtell. The house was constructed many years ago. This suffered comparatively little damage. Only a portion of the roof is gone, one small gable end and most of the glass. On the east front the building is cracked from top to bottom. A large barn near-by is a complete wreck, as well as tenant houses of wood. The trees were turned over but not moved forward excepting where the tops were broken out. These were sometimes carried quite a distance.

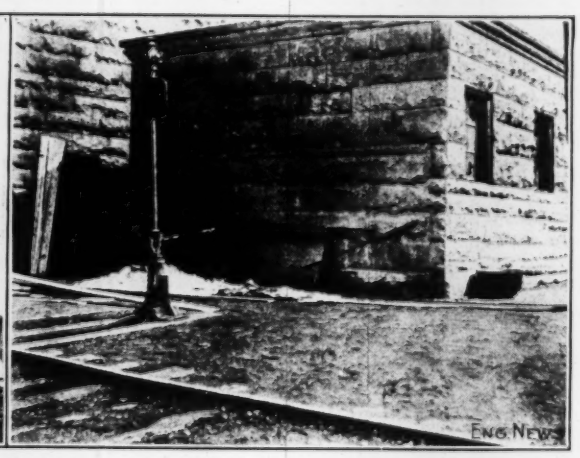
Moving from the Ijams farm towards the city, the storm wrecked a frame house and crossed open fields to a railroad where empty coal cars were turned completely over, the trucks being on top, and then struck the Root glass factory where the wind and a fire which followed did $20,000 to $30,000 damage.

The main portion of the damage in the city was confined to a strip between 400 and 500 ft. wide and two miles long. The buildings were, for the most part, one-story cottages or bungalows. The better class of these lost roofs and windows but the others were completely wrecked, in some cases merely a small pile of rubbish being left. Occasionally roofs were transported some dis-

RUINS OF ROOT GLASS WORKS

VIEWS AT SOUTH 6½ ST.

A SUBSTANTIAL BRICK HOUSE



STONE PUSHED INWARD ON BUILDING

VIEWS IN PATH OF TORNADO OF MARCH 23 AT TERRE HAUTE, IND.

tance, but in general the material was left near its original position.

Buildings which were well constructed of good materials suffered less damage as witnessed by a two-story brick house constructed with 13-in. walls of paving brick. This lost the roof with the ceiling of the second story, the windows and a small portion of the side walls. A good photograph of this building shows the south side. Across the street from this building (east) a stucco cottage was practically wrecked while a well built cottage just north of the stucco building suffered very little damage.

The cottages in many cases were turned on their foundations, some going clockwise and others going contra-clockwise.

Examples of soft wood piercing hard wood occur. Stone copings were torn away and in one case an individual stone in the side of a building was pushed in some three or four inches (see photograph).

The damage done is variously estimated at from $750,000 to $1,500,000. I think $750,000 will cover the entire damages. This includes a loss of $60,000 by Mr. Ijams (who lost fine horses) and $30,000 by the Root Glass Co. The latter lost a goodly portion in the fire following the storm.

FLOOD IN WABASH RIVER OVERFLOWING BRICK-PAVED ROADWAY TO WEST TERRE HAUTE

Fortunately there were but very few fires and these were quickly controlled. Of course the street railway and telephone companies lost wires and poles.

The loss of life totals about 20, which is remarkably small when one considers how thoroughly some of the buildings were wrecked. There were possibly 200 homes in the immediate track of the storm.

In a general way weather conditions were such that weather observers might predict a storm of the tornado type somewhere in the district but the station here recorded nothing unusual other than a quick rise of temperature of some 25°.

Immediately following the tornado the Wabash river commenced to rise and by 7 a.m., Mar. 27, the stage was 31 ft. 3 in., which is about 3 ft. 6 in. higher than any previous record and our records go back 60 years.

The Terre Haute, Indianapolis & Eastern Traction Co. was put out of business for about 16 hours and the city was without electric light, electric power and street railway service. The gas company shut down Thursday morning and did not give any service from Thursday night until Saturday afternoon. Fortunately the water-works company was able to pump water; but it was unable to filter the water efficiently.

The town of West Terre Haute and the settlement called Taylorville, the two having a population of about 1500, were submerged so that all the people had to leave. Thus far four fatalities have been recorded and these were due to exposure.

The Vandalia lines and N. Y. Central lines lost stretches of roadbed west of the city but all bridges here are standing and in use.

The traction company lost its track on the side of the road leading to West Terre Haute. The photograph shows the water flowing over the brick-paved roadway and washing away the fill under the track.

MALVERD A. HOWE.

Terre Haute, Ind., Mar. 31, 1913.

A Valuable Set of Stream Gaging Records

Sir—Hearing this morning that Mr. John E. Codman, of the Bureau of Water, Philadelphia, has severed his connection with the Bureau, I recall an important work which he has carried on since 1883 and up to the time of his retirement, which I consider to be a contribution of great value to the science of hydraulic engineering and which is not generally known. It relates to a record, which has been maintained for 30 years, of the run-off of the Perkiomen, Neshaminy and Tohickon Creeks, near Philadelphia—streams which were at one time considered available as a water supply for that city—and of the Schuylkill, which has been used from the beginning of the city's public water supply in 1801.

In length of time covered, these records are nearly equal to the records of the Sudbury River in Massachusetts and the Croton River in New York, but the special value of the Philadelphia records is that the records are given in much detail. I may mention the automatic rainfall and stream flood gages kept on each watershed and the detailed physical survey, plotted to a scale of 400 ft. to the inch, of the entire watersheds from which the run-off has been continually measured.

By this detailed survey I refer not only to the 10-ft. contour lines, but also to the measurement of the areas which are covered with forests, the roof and road surfaces and the permeable agricultural surfaces. The three watersheds mentioned are topographically different in character, one having its steepest slopes near the periphery, another near the lower areas and the third being somewhat more uniform in slope and more cultivated than the others. By these differences and with a continuous record of rainfall and run-off, the data allow deductions to be made which must be of exceptional value to the profession at large.

RUDOLPH HERING.

170 Broadway, New York City, Mar. 10, 1913.

[We referred the above letter to Mr. Codman with a request for further information regarding these stream gagings, and append his reply.—Ed.]

Sir—Mr. Hering's letter, respecting the Philadelphia hydrographic surveys, might convey the impression that all of the work he mentions was mine; for he refers to

me as having carried on this work since 1883 (when it was begun) and makes no reference to his own connection with it.

As a matter of fact, Mr. Hering himself, beginning in 1883, made the monumental survey of the territory involved; whilst I (rated as Chief Draftsman in the Water Department) took up the work after the close of Mr. Hering's survey in 1888, since which date I have merely remained in charge of the observations and studies of stream flow.

Mr. Hering's survey occupied a period of some three years, and required the services of a highly trained corps of some fifty engineers. It covered all of the country practically available for a water supply to Philadelphia, including large portions of the Schuylkill, Lehigh and Delaware water-sheds. It was divided into investigations for topography, hydrography and sanitation. It was then and it has always since been known, in the Water Department and Bureau, as "The Hering Survey for a Future Water Supply for the City of Philadelphia." It is fully described and illustrated in a special report, bound up with the report of the Water Department for 1886.

Replying to Mr. Hering's concluding query, I have the pleasure to say that his survey is made the basis of detailed statements of maximum, minimum and average stream flows, in the annually published reports of the City's hydrographic survey, of which I have, until recently, been in charge.

JOHN E. CODMAN,
330 So. 42 St., Philadelphia.

March 12, 1913.

A Reinforced-Concrete Building in a Tornado

Sir—In regard to the terrific cyclone experienced by Omaha, Neb., on Mar. 23, the most interesting feature to the engineering profession is the comparison of the effect on the modern and out-of-date methods of construction.

The first large structure encountered was the Medical College of the University of Nebraska, which is just nearing completion at a cost of $100,000. This building (Fig. 1) is L-shaped, 102x100x55 ft., with three stories and basement, of reinforced-concrete and brick, and strictly fireproof. The floors and roof are of reinforced-concrete slab design, supported by steel columns incased in concrete. The outside walls are of brick; the inside partitions are of pyrobar, except for the bearing walls along the halls.

FIG. 1. THE MEDICAL COLLEGE OF THE NEBRASKA STATE UNIVERSITY AT OMAHA, NEB., AFTER THE TORNADO OF MAR. 23

(Steel columns, brick walls and reinforced-concrete slab floors and roof. A row of five new modern houses occupied the lots to the left of the road and just beyond the concrete building. They were completely destroyed.)

After the storm, the building was carefully gone over to ascertain the extent of damage. As to the structural part of the building not a single check could be found. However, a few of the inside partitions were blown down and window frames blown out, but $1000 will cover all damage. The contractor's buildings were all carried away and demolished. The territory surrounding the building was thickly populated and the destruction is plainly evident in the accompanying view.

The next large building encountered was a three-story automobile garage. This building was not fireproof. The exterior was of brick and the interior of slow-burning construction. This was demolished (Fig. 2). Both buildings were in the direct path of the storm.

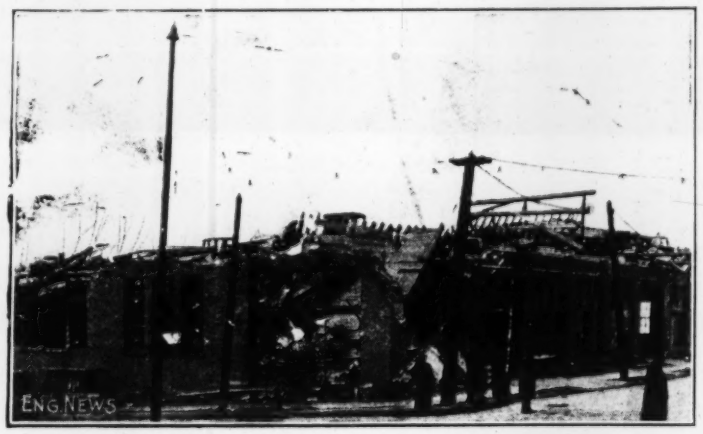


FIG. 2. AUTOMOBILE GARAGE AT OMAHA, NEB., AFTER THE TORNADO OF MAR. 23

(Brick walls and slow-burning interior construction.)

JOHN R. RIPPEY,
Assistant Superintendent of Construction, Grounds and Bldgs., University of Nebraska.
Omaha, Neb., Mar. 29, 1913.

[The college is near Harney and 44th Sts. The garage is at the corner of Farnam and 40th Sts., as noted in our issue of Apr. 3.—ED.]

NOTES AND QUERIES

A. R., Los Angeles, Calif., writes:

In your issue of Mar. 20, there appeared a discussion regarding the status of the engineering profession. There could be no better means of getting at a solution than by having every man belong to the American Society of Civil Engineers, or a corresponding society for his particular line of work, said society to conduct an employment bureau as you suggested. But I do not believe that this would be possible because there are many men well established in the profession who never have and never will contribute a cent to the support of such a society. It is such men as these that make the task of the few who are trying to better conditions doubly hard. I am speaking from experience when I say that the only object these men have in mind is the cutting down of engineering expense in order to satisfy their superiors. The result is that the cheap ones get the jobs and the others either have to amend their prices or go without eating. The effect of this is to cause those who hire engineers to form an idea that the cost of engineering should be very little. So when a first-class engineer comes along and names his price for this or that service it at once conveys to the mind of the employer the idea that the price is just a wee bit high. He figures that so and so would do the same work for half the amount, and the next time there is a similar service to be rendered so and so gets the job. If something is not done, the man with the money will soon have his engineering done for nothing.

For those who are seeking a remedy, I would like to suggest that they start at the beginning. The trouble lies with those higher up, and until some means can be found of getting all those at the top to take an interest in the members there is no use in figuring on better conditions.

Reports from the Flooded Districts

Recent High Water in Pennsylvania Streams

The floods of the latter part of March, 1913, seem to have done relatively little damage in Pennsylvania, compared with Ohio, but the sum total was doubtless considerable. The following summary of the effects of high water in the state is based on information kindly supplied by Farley Gannett, Engineer of the Water Supply Commission of Pennsylvania.

No dam failed, so far as is yet known. Numerous bridges were destroyed, especially in the western part of the state. In the Sharon district a number of building foundations were disturbed, resulting in the destruction of the corresponding superstructures. Many miles of railroad embankment were eroded, both in the west and the east.

By far the worst destruction was wrought along the Shenango and Beaver rivers. The commission is preparing a comprehensive report on what occurred in this district. The report will include precipitation, hydraulic data and damage done, based on material collected by a representative of the commission who was on the ground almost at the beginning of the high water and stayed there until Mar. 31.

The commission also had men in many other parts of the state, taking meter measurements, recording flood heights, taking photographs and collecting data on the damage done. When all the information has been brought together it will make a complete story of high water on all the main streams of Pennsylvania.

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Flood Effects at the Works of the Indianapolis Water Co.

By Charles H. Hurd*

The water-supply for the city of Indianapolis was interrupted from 12:30 p.m., Tuesday, Mar. 25, until 7:00 a.m., Friday, Mar. 28, on account of high water due to the breaking of a city levee along the west bank of Fall Creek. [We understand that this break put the Riverside pumping station out of service.—Ed.]

We suffered no damage which would interfere with our regular operation at our main station or at our filtration plant, except the flooding of some small motors which were used to pump seven deep-rock wells. Conditions are now (Apr. 3) normal with a total pumping capacity of 82,000,000 gal., which is approximately four times our average requirements.

The breaks in the banks of the canal have been repaired and water is now being supplied to our filtration plant from White River, at Broad Ripple. During the time these repairs were being made, our supply was furnished by the emergency station located on Fall Creek.

Our Washington St. or water-power station is temporarily out of service on account of the breaking of the conduit which furnishes the supply to this station. This break was caused by the collapse of the West Washington St. Bridge, which crosses White River at this point. The shutting down of this station will not interfere with our service in any way, as the equipment at Riverside was designed to take care of the maximum requirement at such times as Washington Station might be out of service on account of low water or for other causes.

The proposition is now being considered to strengthen and raise the city levee along Fall Creek and to provide additional waterway to protect the portion of the city in which the Riverside pumping station is located.

The crest height of the present flood was 4½ ft. higher than any other flood of which we have a record.

*Superintendent and Chief Engineer, Indianapolis Water Co., Indianapolis, Ind.

❖

The Flood at Rochester, N. Y.

By E. A. Fisher*

The Genesee River was higher during the floods late in March, 1913, than at any other time since 1864.

The water was about 8 ft. deep over what is known as the Court Street Dam. This was about 4 or 5 in. higher than the high water of 1902. The estimated maximum flow was about 45,000 cu.ft. per sec.

The Genesee River overflowed its westerly bank between Main St. and Central Ave. and flooded a portion of Front St. and adjacent intersecting streets to a depth of from 1 to 3 ft. There was no appreciable current, and the damage consisted in the flooding of cellars in the area covered by the water, and also the flooding of some cellars on Main St. connected with the outlet sewer passing through Front St., which sewer was gorged by the water

The Genessee River in Flood at Rochester, N. Y.; at the Canal Aqueduct

entering through the surface sewers and manholes in Front St.

I have no reliable estimates of the amount of the damage. This damage was lessened, due to the fact that the merchants had considerable notice of the high water and many of them made preparations by removing their goods from the cellars.

The high water was due to a continued rainfall on the upper river. We have no records of the rainfall on the territory. The rainfall at Rochester was comparatively light, as shown by the accompanying table. The highest water occurred on Friday, Mar. 28, between 10 and 12 p.m.

*City Engineer, Rochester, N. Y.

RECORD OF RAINFALL AT ROCHESTER, N. Y., MARCH 20 TO 28, 1913

(Total for month, 5.16 in.)

	Inch
March 20	0.42
March 21	Trace
March 22	Trace
March 23	0.21
March 24	0.40
March 25	1.06
March 26	0.77
March 27	0.65
March 28	Trace

The Effect of the March Floods on the Terre Haute Water-Works

By Dow R. Gwinn*

The tornado of Mar. 23, 1913, which caused a loss of over 20 lives and a property damage of perhaps $1,500,000 in Terre Haute, Ind., was followed by an unprecedented flood. During this flood the river rose to a level of about 31 ft. 3 in., as nearly as we could measure, all gages being submerged. The river was 4.7 m. higher than during the last flood of 1883 and when the new gages were established, no one dreamed of the water reaching the height of even 30 ft., so provision for such a height was not made.

The gas plant and the electric-light plant on the river were put out of business, but, fortunately, we were able

Flood Conditions at the Pumping Station of the Terre Haute Water-Works on Mar. 27, 1913

(The river height was 31 ft. 3 in., as nearly as could be told. The building to the right contains old pumps, not in use. At the extreme left a bit of the corner of the Allis-Chalmers pump room is shown. The vine-covered building in the center is the old boiler room, the boilers in which were submerged. In the right background is the bridge of the Big Four R.R.)

to keep the water-works plant in operation so far as the general service was concerned.

We have an Allis-Chalmers triple-expansion vertical pumping engine in a reinforced-concrete pit 21 ft. deep and approximately 45x45 ft. in plan. The bed plate of the engine is on the floor level; that is, 21 ft. from the bottom of the pit. The water came within about 18 in. of the floor level.

The concrete pit was separated from a brick pump pit by a brick wall. The brick pit was made of very heavy walls (I should judge about 2 ft. thick) but these were not impervious to the water and we had considerable leakage. Then later on, the water flowed over the brick wall partition, flooding the Allis-Chalmers pump pit. The water did not interfere with the operation of the high-service pump, but in this same pit is also located our low-service pump, which delivers the water to the sedimentation basin. It is a centrifugal pump operated with a rope drive from a Williams compound engine, located on the floor level. After the water reached the level of the rope drive, about 2 ft. from the bottom of the pit, we were compelled to shut down the pump.

As the turbidity was in the neighboorhood of 1200 to 1500, it was impossible to get good results from the filters, although they were washed four or five times in one day. The settling basin was cut out for about 15 hours, during which time the water pumped into the mains was anything but satisfactory. However, the citizens of Terre Haute were very much pleased to have any kind of water, as neighboring cities were cut out of a public water-supply entirely.

As soon as we can do so, we will raise the brick division wall and endeavor to make it impervious to water by proper treatment. We will also arrange for better facilities for pumping flood water from the pit and are considering the installation of a 6-in. centrifugal pump direct connected with a steam turbine. We are also considering the idea of installing a low-service centrifugal pump with a vertical shaft and vertical steam turbine to deliver water into the settling basin, the idea being to have the turbine several feet above the highest water.

We were well pleased with the result of the flood test of the concrete pit. This pit was built under plans made by Prof. Daniel W. Mead of the University of Wisconsin, the walls being 3 ft. thick at the bottom and 2 ft. at the top, with ample reinforcement. We did not use any waterproof compound in the concrete mixture, but took great care to have a strong liquid mixture. We used a gravity mixer and had unusually good forms or boxes, and spades were used to keep the coarser material from lodging next to the forms. After the forms were removed, the outer surface of the walls was covered with Tarsch Bros. R. I. W. marine paint, care being taken to have every portion of the wall covered. The bottom of the pit was laid in several layers with a coating of the marine paint between the same. Notwithstanding the fact that the water from the river was very close to the top of the 21-ft. walls, we did not find a single leak at any place in the concrete walls.

*President and Manager of the Terre Haute Water Works Co., Terre Haute, Ind.

Flood Damage at Sidney, Ohio

By W. R. Blake*

Sidney, Ohio, was greatly damaged by the recent flood, but on account of the favorable location of the city as regards the river the damage did not amount to nearly so much as at the lower towns, Piqua, Troy and Dayton, Piqua lies 12 miles south of Sidney, Troy 20 miles and Dayton 40 miles, all lower down the river.

The greater part of Sidney lies well up on high ground and most of the residence district is located on rather high hills. Besides this advantage there is a rather sharp decline of the river bed and the water flows rapidly and does not have a chance to back up.

The other towns mentioned are not built on such high ground, and besides this there was a tendency for the water to form basins at these places, especially where there happened to be certain obstructions favorable to make those conditions, such as bridges and railroad embankments.

This city was in total darkness for a time, many elec-

*City Engineer, Sidney, Ohio.

tric-light wires being down and gas mains being broken. The sewers were out of commission in the lower part of the city. The water-works, being well up, was not put out of commission, but the only water-supply available was muddy river water, as the wells were overflowed.

A total of 7.8 in. of rain fell between Sunday noon (Mar. 23) and Monday night or early Tuesday morning. The rain came in a steady downpour. As far as can be learned this heavy rain fell over such a large territory as to entirely fill all streams beyond their capacity. Besides the above rain the condition of the ground was rather wet, rain having fallen very steadily for three or four days during the previous week, ending Friday night.

By very hard work to save them, no bridges were completely destroyed in Sidney, although some of them were badly damaged. The loss of bridges and roads in the immediate vicinity of Sidney is estimated at $125,000 to $150,000. About six or eight houses were completely washed away in this city.

The Floods in New York State and the Work of the State Department of Health

The damage wrought by the floods of March, 1913, in New York State was largely concentrated in the "Capitol District." Some damage was done at Rochester, as stated in a brief report from E. A. Fisher, published elsewhere in this issue. The extent of the damage done to the Barge Canal has not yet been officially announced.

Up to Apr. 1, 1913, we are informed by Alex. Rice McKim, inspector of docks and dams, State Conservation Commission, only eight dams had been reported as having been damaged to any considerable extent. These were small, and of either earth or crib construction. All of them were old dams, built before the Commission was established.

The flood of a year ago (April, 1912) carried out several times as many dams as that of 1913, Mr. McKim having inspected 22 failures out of a larger number which occured in 1912.

The gaging stations of the Conservation Commission were all in working order, so flood data for the entire state will be available later on.

Considerable portions of Troy, Watervliet and Albany were inundated, practically paralyzing the trolley service and, in sections, the electric-light service as well, besides causing heavy damage to water-front industries and some suffering among residents.

The water-filtration plants of Albany, Rensselaer and Green Island were thrown out of service by the flood. Full particulars as to the Albany plant are given elsewhere in this issue. The following particulars regarding the Rensselaer water-supply are from a correspondent:

The filter plant is located on the banks of the river and when the floods arose the pumping station was submerged sufficiently to put it out of commission so that no water could be pumped into the system. The city has a distributing reservoir but unfortunately the main pipe line from this reservoir broke as a result of a washout so that the city was entirely without water for about two days, Friday and Saturday. As soon as the pipe could be repaired, which was in about 48 hours, the city system was put in operation, and water has since been supplied regularly to the citizens. Before its storage was exhausted the river had lowered so that the pumping and filter plant could be put in operation, from all of which it is evident that, except for the two days during which the people had to rely upon wells or water from any source from which they could secure it, the water-supply system was in operation. There was no pollution of the water in the reservoir and consequently outside of the two days' interval referred to, filtered water has at all times been supplied to the citizens.

The Rensselaer filtration plant is supplemented by a permanent hypochlorite plant, which has been in continuous operation for about two years.

The Green Island water-filtration plant and well system was flooded for two days, but sufficient storage was available to supply the consumers without drawing on the untreated river water.

The Troy water-supply is by gravity from the hills and was not affected by the flood. The Watervliet supply was not shut off by the flood.

Outside the "Capitol District" there were practically no reports of polluted water up to April 1, except that the ground water-supply area of Oswego was flooded with water believed to be polluted. Samples were collected for analysis by the State Department of Health and the people were warned to boil the water.

Before the flood reached its height Dr. Eugene H. Porter, State Commissioner of Health, sent warnings through the Associated Press and by telegrams to the most important cities of the state urging the authorities in control of threatened water-supplies "to use every safeguard to protect these supplies and to notify the public of the safe precaution to boil all water until all effects of flood conditions have passed."

On Saturday, Mar. 29, Governor Sulzer took up the Albany water-supply situation with the State Department of Health (the city had already acted, as stated in the article by Mr. Greenalch, elsewhere in this issue). The department pointed out to Governor Sulzer that to bring in drinking water by rail, as the Governor had suggested, would give rise to difficulties if not to dangers. The department advised that faith should be pinned to boiling water used for drinking purposes. To remove or lessen the turbidity of the water a plan for household treatment was outlined by Theodore Horton, chief engineer of the department, as follows:

> Add 1 oz. of alum to 1 bbl. of water, or for smaller volumes at the rate of 1 level teaspoonful to 3 gal., and let it stand over night. The clarified water should be boiled subsequently. The "flat" taste of the boiled water may be removed by pouring the water, as wanted, into a glass held 12 to 18 in. below a pitcher. It is advisable to pulverize the alum, then dissolve it in a small quantity of water before the alum is admitted to the water to be clarified, and the water should be stirred after the solution is added.

Dayton, Ohio

In Dayton every effort is being directed toward making the city livable and no accurate estimate of the damage has been made. The flood stage reached approximately 29 ft., the highest previous record being 21.8 ft. The levees were designed for a stage of 25 ft. Two steel highway bridges and two spans of a steel railway bridge were washed away but all of the concrete arches are safe. The levees, being overtopped, were badly riddled and asphalt pavements in the flooded districts ruined. [By telegram from Gaylord C. Cummin, City Civil Engineer.]

The Recent Flood at Columbus, Ohio

By Julian Griggs*

The extraordinary rainfall of Mar. 23-27 over the drainage areas of the Scioto and the Olentangy Rivers produced record high water in the two rivers at their confluence in the City of Columbus, Ohio, and caused flood damage and loss of life without precedent in the history of the city. The Olentangy River has a drainage area of about 514 sq.mi. and the Scioto a drainage area above the city of approximately 1050 sq.mi. The flood plain of the valley at Columbus is about two miles east and west from bluff to bluff, and the well settled portion of the same north of Mound St. to the Scioto River averages a mile in width (see map, Fig. 1). At the beginning of the flood week it was occupied by a population of approximately 30,000, generally living in comfortable frame houses, having an average value of about $2500. It also had its fair share of factories, stores, shops, schools, hospitals and churches.

The Scioto River,† after passing over the Storage Dam, about 1½ mi. above the confluence of the two rivers, runs through a narrow valley descending at the rate of approximately 5½ ft. per mi. for about four miles to the corporation line at the mouth of the Dry Run, located at the foot of the western bluff. Thence the Scioto flows under the bridges of Grand View Ave., the Big Four Ry. and Sandusky St. to the Hocking Valley Ry. (north crossing), being joined just above that bridge by the Olentangy and passing on the way the water-purification works and the municipal electric-light plant in a meandering channel two miles in length. Thence it flows southeast, south and southwest for 1½ mi. under eight bridges spaced 0.085 to 0.284 mi. apart to the Mound St. bridge; thence south and southeast for 1.4 mi. to Greenlawn Ave., generally along lands devoted to market gardens; thence south through farming lands passing the City R.R. bridge, the sewage pumping station, the Frank Road bridge, the city purification plant and the garbage-reduction works in a distance of 2 mi.; thence about 1½ mi. in a wide, alluvial bottom to the mouth of Big Run.

Flood of 1898—The record flood in the rivers previous to this year was in 1898. In that year the high-water slope of the river in the first two miles east of Dry Run was then 2 ft. per mi. From the Hocking Valley Ry. (north crossing) to Greenlawn Ave., a distance of 2.8 mi., it was 4.83 ft. per mi.; thence to the mouth of the Big Run, 3.46 mi., it was approximately 2.37 ft. per mi. The profile of this high water, with the location of the bridge and the works as above noted, is drawn to scale in Fig. 2. The steep slope of high water the Sciotio River, for the section of which State St. is the approximate center, is due to the throttling of the stream by encroachments upon the channel and the contractions at the bridges. The Broad St. bridge affords the smallest opening, being only 290 ft. at right angles to the thread of the current, including one pier.

Present Levees and Embankments—The Scioto has a levee on its western bank from the natural bluff at Dry Run to the garbage-reduction works south of the city, a distance of a little more than 7 mi. This levee had been in process of construction for many years, but was completed, after the flood of 1898, to a uniform height of 6 ft. above the high-water marks of that year. About one-half of this levee was occupied by a railroad track in daily use.

It should further be observed that a separation of the grade of the streets and the four railways passing through the flood plain south and west of the Scioto River had

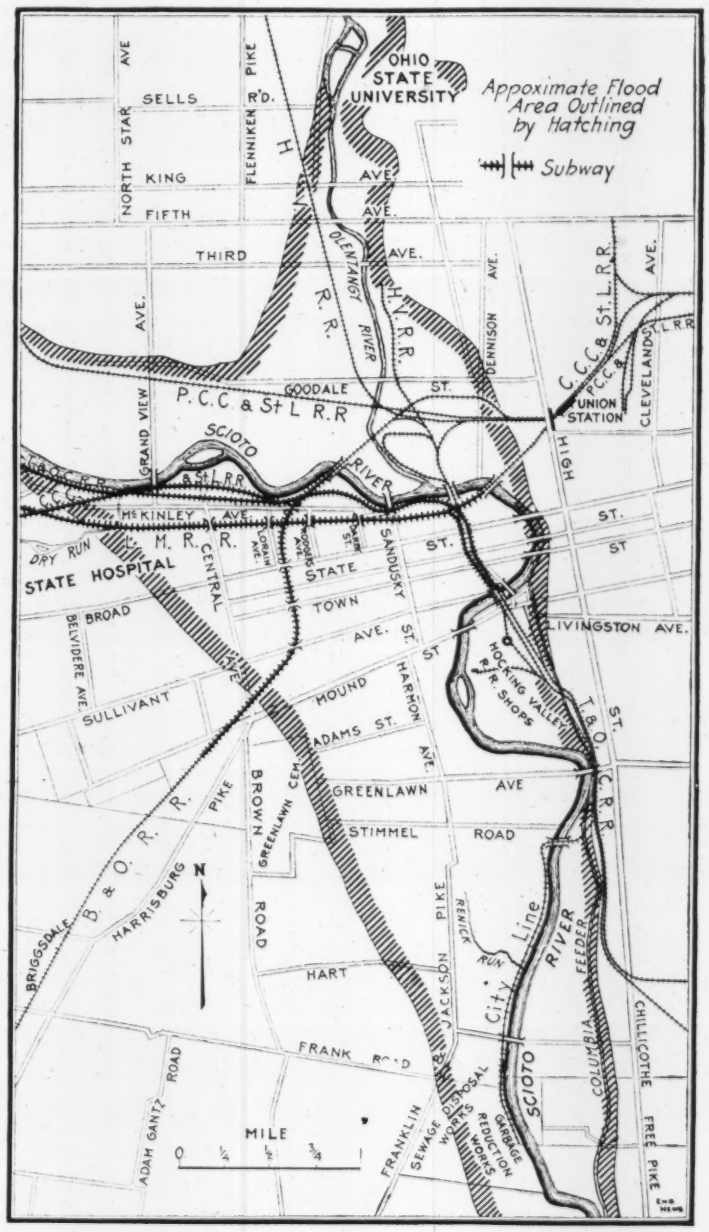

Fig. 1. Map of Columbus, Showing Extent of Recent Flood

(Only important streets shown; levee and railway embankments indicated by heavy black lines.)

just been completed in accordance with the best present-day standards for such construction. The railroad embankments had nearly the same elevation as the top of the adjacent levee, except in one place, at the joint crossing of the Little Miami, Hocking Valley and Toledo & Ohio Central Rys. (Fig. 5) which was 5 ft. below the levee

*Chief Engineer, Lancaster Traction & Power Co., Columbus, Ohio.

†The entire new water and sewage works of Columbus was described in an extensive paper entitled "The Improved Water and Sewage Works of Columbus, Ohio," by John H. Gregory, in the "Transactions" of the American Society of Civil Engineers, Vol. 67, 1910, p. 206. The so called "Storage Dam," noted throughout Mr. Griggs' article forms the reservoir from which the water-supply is taken. It is a concrete structure of gravity section, about 1006 ft. long, consisting of two abutment sections, one on each bank of the river with an overflow section between. The overflow section is at El. 73, low water being at El. 43, and is 500 ft. long. The section is such that the overflow portion can in future be raised to the same elevation as the abutment sections, that is, to El. 117.—Ed. "Eng. News."

grade to permit the subsequent raising of the L. M. R.R. for an overhead crossing of the other railroads at that point. The L. M. R.R., west of this crossing had five street openings through its embankment at Sandusky St., Darby St., Rodgers Ave., Lorain Ave. and Central Ave., spaced about 1100 ft. apart. The Baltimore & Ohio R.R. embankment was pierced by four subways located at McKinley Ave., Broad St., Town St. and Sullivant Ave.

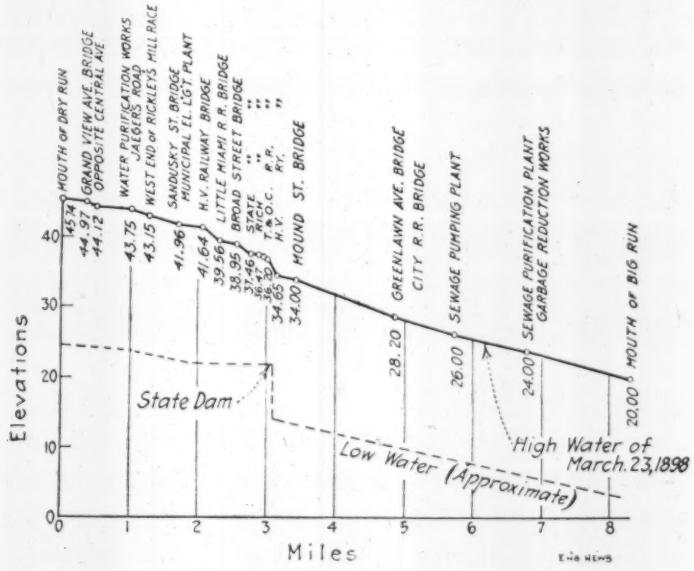

FIG. 2. PROFILE OF SCIOTO RIVER DURING RECORD FLOOD OF MARCH, 1898

It was known by a few who had made a study of the situation, that the river channel would ultimately have to be widened in the vicinity of Broad St., and for that reason extensive expenditure in the construction of high concrete levee walls at this point was avoided. It was known that no money for the widening of the river channel at this point could be had until a calamitous flood should occur to bring the community to a realization of the necessity for such enlarged channel, but no one ever had an imagination sufficient to visualize, in his mind's eye, the awful magnitude of the calamity when it finally came, nor the extent of the new works required adequately to meet the demands of the situation.

The flood of Mar. 23, 1898 was the greatest known up to that time. It was estimated that by providing a levee 6 ft. higher than that flood, a margin of 25% for greater floods would be secured.

From the best available data the maximum discharge of the river in that flood was estimated by an expert engineer as 75,000 sec.ft., of which ⅓ or 25,000 sec.ft. was assigned to the Olentangy and 50,000 sec.ft. to the Scioto River.

FLOOD OF 1913

Fig. 3 shows a plotted curve of the gage readings on the crest of the storage dam in the Scioto from 7:30 p.m. on Mar. 24, 1913, to 9:30 a.m. of the 28th. The table herewith also shows the rainfall

U. S. WEATHER BUREAU RECORD OF RAINFALL IN INCHES

Date 1913	Bellefontain, Logan Co.	Marion, Marion Co.	Columbus, Franklin Co.
March 23, p.m.	1.37	1.23	0.53
March 24, a.m.	1.52	1.02	0.09
March 24, p.m.		1.12	1.94
March 25, a.m.	5.61	3.65	0.68
March 25, p.m.		1.06	1.14
March 26, a.m.	2.13	1.03	1.58
March 26, p.m.		1.00	0.55
March 27, a.m.	0.53	0.50	0.46
March 27, p.m.			trace
Total	11.16	10.71	6.97

record of the U. S. Weather Bureau for Columbus, and at two points in the drainage area of the Scioto, 45 mi. above this city for four days beginning at noon on Easter Sunday, Mar. 23. It will be noted that the heaviest rainfall of any 24 hours occurred at Bellefontaine on the 25th and was 5.61 in., with Marion 4.71 in. on the same date, while the total precipitation for the four days was 11.16 in., 10.71 in. and 6.97 in. at Bellefontaine, Marion and Columbus, respectively.

The runoff from this rainfall caused a rapid rise at the Scioto River Storage Dam.* The head on the round-topped weir, 500 ft. in length, is plotted to scale in Fig. 3 and shows a head of 10 ft. at 8 a.m. on Tuesday, the 25th, when the channel capacity of 63,246 sec.ft. was passing. The river began to flow over the levee at a point five miles below at 9:25 a.m. of the 25th.

The discharge shown in Fig. 3 was computed by the Francis formula with 4 as a constant for a round-topped weir ($Q = 4 \times 500 \times H^{\frac{3}{2}}$). It will be noted that the river continued to rise and reached its crest of 12.9 ft. at 1:39 p.m., 5½ hours later. By the same weir formula above noted the maximum discharge was 92,665 sec.ft. or 46% in excess of the channel capacity on a 10-ft. head, and the discharge continued in excess of

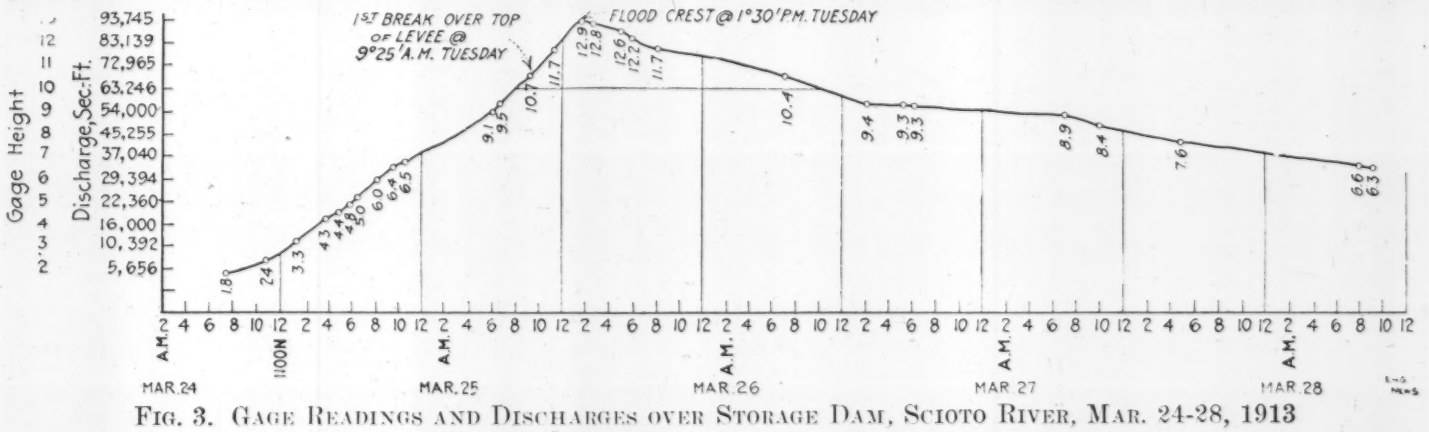

FIG. 3. GAGE READINGS AND DISCHARGES OVER STORAGE DAM, SCIOTO RIVER, MAR. 24-28, 1913

(Discharge = $Q = 4\ L\ H^{3/2}$.)

such capacity for a total of 26 hours, until 10 a.m. of Wednesday, Mar. 26. In the meantime the earth levee

*Mr. Gregory's Am. Soc. C. E. paper says in regard to the overflow section of the dam: "The overflow is 500 ft. long and was designed to discharge a maximum rainfall of 6 in., on the drainage area of 1032 sq.mi. above the dam, flowing off in 24 hours, or about 166,500 cu.ft. per sec. To discharge this quantity would require a depth of about 21.7 ft. on the overflow."—Ed. "Eng. News."

was overtopped at all points west of the L. M. R.R. bridge, badly damaged in numerous places and totally destroyed at six gaps aggregating 3300 ft. in a length of 2.75 mi. This length includes 0.50 mi. along the east and south bank of Dry Run, which had only one gap of 69 ft., located on the State Hospital grounds near the bluff at its western end.

it were to be seen blocks of sandstone coping from the abutment 3x5 ft.x18 in. transported by the current. Ten substantial frame dwellings, which were immediately below this break, had disappeared, having been destroyed or floated away.

After passing the L. M. R.R. tracks at Central Ave., Loraine Ave. and the break at the B. & O. R.R. crossing,

FIG. 4. SULLIVANT AVE. SUBWAY, B. & O. R.R., COLUMBUS, OHIO, LOOKING SOUTH

FIG. 5. B. & O. R.R. AND LITTLE MIAMI R.R. CROSSING LOOKING NORTH

FIGS. 4 AND 5. BREAKS THROUGH RAILWAY EMBANKMENTS, COLUMBUS, OHIO

As soon as the levee was overtopped, as above noted, the flood in great volume poured into the basin ¼ mi. wide and a mile in length, bounded by the L. M. R.R. and B. & O. R.R. track-elevation work and passed with a tremendous scouring velocity seeking an outlet through the three subways at Central, Lorain and McKinley Aves. This basin was soon filled with water 16 ft. deep, and the railroad tracks, which at this point had substantially the same elevation as the levee above them, were overtopped at the crossing of the two railroads. Of the 16-ft. high embankment, 600 ft. long on the L. M. R.R. and 400 ft. on the B. & O. R.R. was totally destroyed, and in addition holes were washed in the natural ground upon which they rested.

the water passed on and again piled up west of the B. & O. R.R. at Sullivant Ave., filling that subway and topping the embankment for more than 400 ft. at the dip in the grade there (base of rail elevation 43.17 ft.), causing the water to accumulate in a few moments to a depth of 17 ft., rising high over the second-story floors of dwellings in a populous and desirable residential section, thus driving the inmates up into their attics, where such a refuge was available. From the Sullivant Ave. subway the water had a free outlet into low ground, where its flow was unobstructed. The numerous frame dwellings in its path yielded quickly to its destructive action, the north abutment of the subway was destroyed and a single line of rails on the 28th remained suspended for 180

FIG. 6. LOOKING SOUTHEAST

FIG. 7. LOOKING WEST

FIGS. 6 AND 7. VIEWS FROM SULLIVANT AVE. CROSSING, B. & O. R.R.

At Central Ave. the force of the current undermined the east abutment of the subway and the embankment behind it for 150 ft. in length. At the time it was viewed, about noon on Friday, Mar. 28, although the water had then fallen 12 ft., a small corner of the destroyed abutment was projecting above the water at an angle of 45°. Where the embankment rested was water 15 ft deep, with a strong current. Gravel from this hole was deposited over the rear yards east of Central Ave. for perhaps 4 ft. in depth, at a distance of 400 ft., and among

ft. above the gap, as seen in the view in Fig. 4. Fig. 6 is from a view also taken from the top of this same embankment; looking southeast at this location is a picture of a few of the damaged dwellings remaining. It shows distinctly the high-water mark on the brick dwelling in the middle distance.

Fig. 7, also taken at this place, looking west, shows houses which were in the most deeply flooded district where the water was 17 ft. above the street grade. The frame dwelling in the left foreground shows a hole in

its gable end through the weather-boarding into the attic, caused by floating drift, or possibly made by design in effecting a rescue of its inmates.

Fig. 5 is a view of the location of the B. & O. and Little Miami Ry. crossing, looking north from the top of the B. & O. embankment, and shows in the left-hand foreground the destroyed brick building of the Hayden-Corbet Chain Works. In the left-hand distance is a corner of the T. & O. C. R.R. roundhouse, where two bodies were recovered. The Big Four R.R. ran east 100 ft. or so, north of the roundhouse on top of the levee, which has been washed away and wholly destroyed. The McKinley Ave. subway just beyond the signal tower in the right-hand middle ground has settled and cracked, and the B. & O. embankment beyond it is washed away as well as those of the T. & O. C. and Big Four companies.

Fig. 8 shows a gravel deposit to within 6 in. of the top of a first-story window. In advance of the flood this location would have been selected as a place of great se-

FIG. 8. VIEW SHOWING GRAVEL WASHED UP TO FIRST STORY OF HOUSE

curity protected as it was, first, by the levee on the river bank and then by two heavy railway embankments, each carrying a well constructed double track. When the flood topped them, however, they soon melted away and the released waters carried destruction to property in its path.

The havoc wrought by the flood in the territory east of the B. & O. R.R. to the Scioto River is similar to that above described. Many photos showing wreckage like that illustrated in Fig. 9 might be furnished.

An incident of the flood was a rumor at 4:30 p.m. on Wednesday that the Storage Dam had burst. Messengers on horseback and the telephone quickly spread it over the city and many, on higher ground than the surface of the reservoir itself, frantically tried to climb into lofty buildings, struggling for places of preferment until the rumor was officially declared false by other messengers sent out for that purpose.

It is interesting to note that the flood caused but little damage to the new sanitary works of the city. About 2 p.m. on Tuesday the pump at the new water station, which had been gradually increasing its discharge, lost its pressure altogether when the 36-in. main to the west side at the Sandusky St. bridge was washed out by the breaking of the levee and could not be shut off for 24 hours till the subsidence of the water permitted access to to the valve at the intersection of Dublin pike and Sandusky St. The concrete floor in the pumping station over the space reserved for pumping unit No. 3 was lifted about 8 in. by the ground-water pressure, but settled back into place again as the flood receded.

At the sewage-purification works the levee surrounding the plant was injured only at one point, 300 ft. in length, when it was cut away beyond its center line at the northwest corner, but a few sand bags prevented a break admitting the back water. The men operating the sewage pumping station participated in the panic occasioned by the rumor of the burst dam to the extent of deserting their posts and allowing about 2 ft. of water to accumulate over the floors.

There was a maximum of 28 ft. of water over the apron of the storage dam (El. 40) the elevation of this tail water being 68 ft. city datum. The crest elevation of the weir is 73 ft. and with 12.9 ft. of water above the crest the difference of level between the water above and below the dam at its maximum flood stage was 17.9 ft. When the water had fallen 10 ft. to a depth of about

FIG. 9. FLOOD WASHING OVER BIG FOUR R.R. TRACKS

18 ft. over the apron, large stones deposited by the current were just visible 200 ft. below the dam at its eastern end. After the flood subsides it will be interesting to note to what extent, if any, the channel in the rock immediately in front of the apron has been deepened by the backlash of the water. It is apparent, as expected, that it has been extended down the stream for possibly 100 ft.

The levee just south of Mound St. for 500 ft. was broken and destroyed, and also in several short gaps north of Greenlawn Ave. where it was overtopped, but elsewhere the city levee was not damaged except as herein noted.

The Government gage on the Mound St. bridge indicated a maximum of only 1.6 ft. above the 1898 flood, which was quite misleading, because of the volume of flood water taken out of the channel and turned through the west side for two miles above the L. M. R.R. bridge.

BRIDGES—Of the 15 bridges spanning the Scioto from Grand View Ave. to the City R.R., inclusive, and of the 10 bridges on the Olentangy, all 25 bridges being within the city limits, only two were completely destroyed and two others lost one or two spans, as noted in the table below. The bridges damaged within the city limits were as follows, all being truss bridges:

Town St.—pier failure—two center spans—11 a.m. 3/25.
State St.—pier failure—whole bridge—11:30 a.m., 3/25.
Broad St.—abutment failure—west span—11:30 p.m., 3/25.
Mound St.—abutment failure—whole bridge—5:20 a.m., 3/26.

Between the city and the Storage Dam several other failures may be noted. The first, at the stone quarries, 1.5 mi. below the dam, was an old iron Pratt truss railroad bridge re-erected not very high above the water, crossing the stream at right angles. Probably if it had resisted the flood, high water would have reached nearly to the top of the trusses, as the valley was very narrow. Sixteen miles above the dam an old wooden covered bridge was carried away and, according to the testimony of an employee at the dam, it passed over that structure without breaking up, so that the stone quarry bridge noted above, together with the Robinson highway bridge (which was washed away), 1.6 mi. below the dam, and the Pennsylvania R.R. bridge, 2.2 mi. below the dam, were all in line for what shock might occur from heavy drift. The Pennsylvania R.R. bridge noted carried its track on a double-track deck structure 50 ft. or so above the water in three spans of 150 ft. each. The water did not reach the lower chord by about 3 ft., but drift to some extent lodged in the defective pier, which appeared to have been undermined a little at its head, although supposed to have been founded on solid limestone.

Below the city the following bridge failures are reported:

At Chillicothe, 50 mi. south of Columbus, the Scioto is reported to have been about 8 ft. higher than ever before. The Scioto Valley Traction Co. lost the north pile trestle approach (1500 ft.±) to its bridge, except one section of 50 ft. which had been weighted with a steel girder crossing. It also lost the embankment leading to the trestle and had its track washed off and overturned. About half a mile beyond this crossing of the Scioto, the Norfolk & Western R.R. Co. had a new structure, consisting of four channel deck-plate girders of 100 ft.± and about seven shorter deck girders crossing above the bottom lands, all set on stone piers on piles. It lost all of the short spans, the north abutment and the north channel span by the undermining of the foundations, so that a fragment of one pier of those destroyed can now be seen above the water surface.

One span, the east span, of a large steel highway bridge over the Scioto River at its mouth, at Portsmouth, was lost in the flood, due to erosion and slip of the abutment into the stream. A bridge of the Scioto Valley Traction Co. at Reeses, Ohio, 7.5 mi. southeast of Columbus, consisting of two 110-ft. spans over the Big Walnut River, is now resting on piers which foot on piles standing up about 10 ft. above the eroded bed of the stream. A Norfolk & Western R.R. bridge just above this latter bridge, in which the masonry of the abutments joins the previously noted structure, had its south abutment undermined by a wild eddy of water flowing in across the bottom land to the south, so that its piles were likewise exposed. The railway company dumped several carloads of stone in behind with the thought of protecting the abutment, and so pushed it into the river.

Damage

The Columbus Building Department has made careful investigation of the West Side, and gives out the following conservative estimate of damage:

300 houses wholly destroyed at $2000	$600,000
200 houses damaged to the extent of $3200 each	640,000
Loss of clothing and damage to personal property	260,000
Total	$1,500,000

The number of lives lost is reported at 85.

Proposed Remedies

Remedies for future floods have been suggested as follows:

(1) Fill the west side to a grade above floods.

(2) Abandon the territory to parks, playgrounds and municipal gardens.

(3) Raise the levee to a greater elevation.

(4) Provide additional river channel or channels.

(5) Widen the existing channel.

No. 1 involves the loss of a large part of the value of the existing pavements, sewer, water, gas and other pipes, and the recent large expenditure for grade separation by track elevation, with great additional expense for the filling and changes required. It is probably beyond the financial resources of the community.

No. 2, a rough estimate of the present value for taxation of the two square miles of well built up and populous low-ground territory is $20,000,000, a sum which makes it evident that this thought of a remedy occurs too late in history to be useful. It is suggested that the community organize now to protect itself against the creation of other "west sides" by the occupation of low unsuitable areas with truck gardens rather than dwellings.

No. 3. In the light of the lessons to be drawn from this recent flood the limit of advisable levee height would seem to have been already reached.

No. 4 and 5. The problem involved in a design for a river channel of adequate capacity, which shall not be self-destructive under the widely varying stages of the river, together with the related questions of sewerage and drains, the whole running into an expenditure calling for a sum of money which can only be expressed in seven figures, cannot be answered offhand, but will tax the capacity of the highest order of engineering talent.

The city, however, is hopefully looking towards its future.

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Coöperation in Irrigation Development between Federal and State authorities on a new plan has been initiated by Secretary of the Interior, Franklin K. Lane, in a contract approved by him between the United States and the State of Oregon. At a conference held in his office at which were present Secretary Lane, Director F. H. Newell, of the Reclamation Service, Senator Chamberlain, of Oregon, and John H. Lewis, State Engineer of Oregon, a formal agreement was signed which provides for coöperation between the Federal Government and the State of Oregon in the investigation of irrigation and power projects. The Secretary agrees to withdraw the necessary land and the State Engineer agrees to hold the necessary water for the irrigation of projects under investigation. Any project or unit may be released for construction by private capital upon payment of the cost of preparing plans, providing such development will be carried out in harmony with the public plan for the highest utilization of the waters of the State.

The sum of $100,000 is now available, half of which is contributed by each party and will be expended largely on the investigation of the 300,000-acre Deschutes River project starting immediately on the Tumalo Creek unit of 35,000 acres. The State has appropriated $450,000 for the partial construction of this unit and Secretary Lane has agreed to allot an equal amount for construction of the entire project in coöperation with the State.

The Oregon Legislature has submitted a constitutional amendment for the vote of the people authorizing the issuance of bonds for the construction of irrigation and power projects. To complete the Deschutes project will require about $8,000,000. Secretary Lane stated that he was in sympathy with the entire plan of coöperation and if the State of Oregon would put up $4,000,000 toward the construction of this project, it was his opinion that an equal amount of money could be allotted fro mthe Reclamation Fund by that time for this work in Oregon.

The Flood of March 25 at Akron, Ohio

[Special Correspondence]

The city of Akron, Ohio, and the county of Summit, in which it is located, have during the past week presented the unusual spectacle of territory located on the crest of the divide separating the watershed of the Great Lakes from that of the Ohio River suffering heavy loss from flood.

The greater part of the city drains into the Cuyahoga River through the Little Cuyahoga and the Ohio Canal (see map, Fig. 1) both of which pass through the heart of Akron, and ultimately into Lake Erie at Cleveland. The Little Cuyahoga River has its source about eight miles east of Akron and flows through the city in a deep valley, entering the Cuyahoga just north of the city limits. Its watershed is about 50 sq.mi.

The Ohio Canal is fed by the Tuscarawas River, which flows in a westerly direction, passing about three miles to the south of the city. The waters of this river are stored in a series of semi-artificial reservoirs, known as the Portage Lakes, to the amount of about 1,250,000,000 gal. From these lakes not only the summit level of the

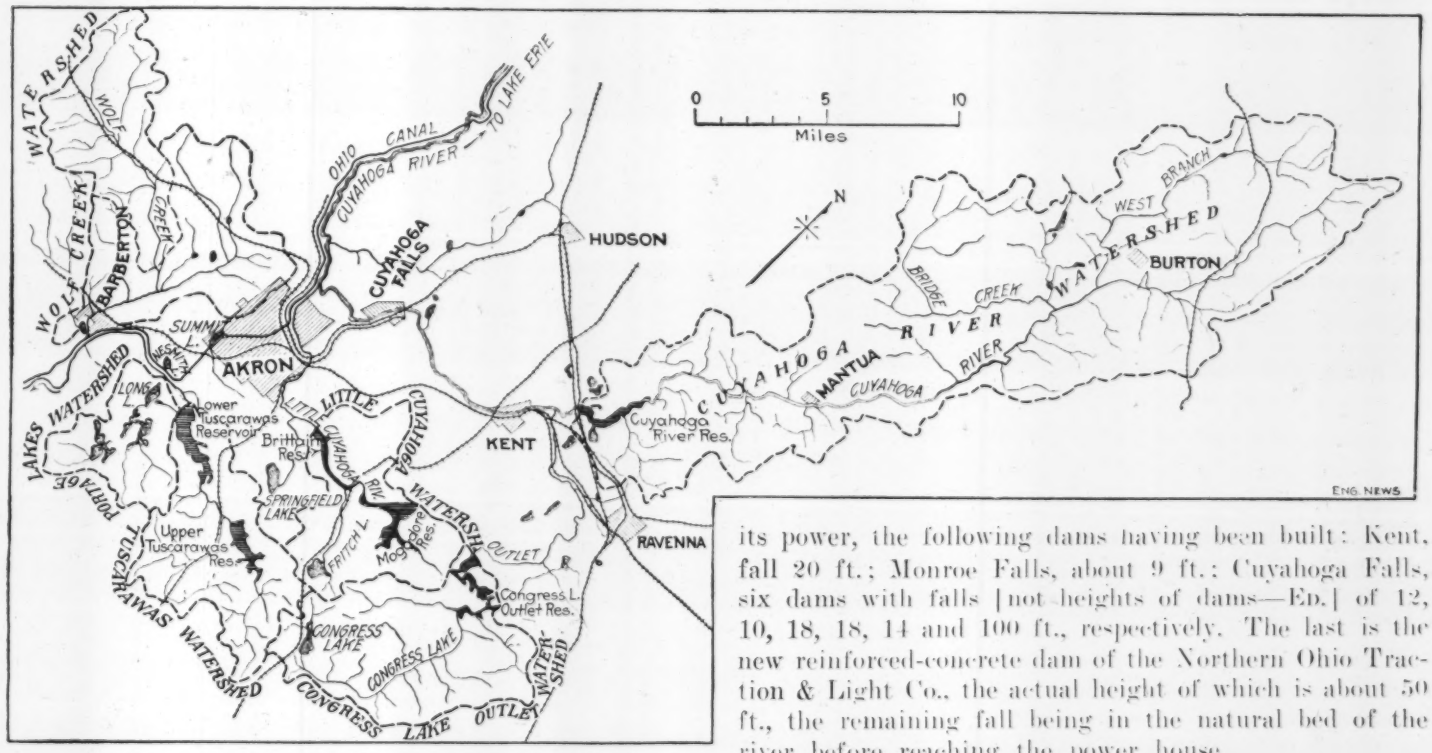

Fig. 1. Map of Akron, Ohio, and Vicinity, Showing Rivers, Reservoirs and Canal Which Caused Flood Damage

canal, but the city of Akron and several large industrial plants derive their present supply of water. The lakes and canal are controlled by the State of Ohio.

The canal falls rapidly through Akron, there being 21 locks with a total drop of about 200 ft. before reaching the approximate level of the Cuyahoga north of the city. This fall was formerly utilized to some extent for small power plants but the small quantity of surplus water available for this purpose has caused the virtual abandonment of these powers.

The combined watershed of the Tuscarawas and the Portage Lakes is about 50 sq.mi. The Tuscarawas lies in the Ohio River drainage area, flowing south to the Muskingum. The Portage Lakes were constructed at intervals, beginning about 1840, by throwing up earth embankments along the northerly side of a natural basin. These banks, as far as can be learned, depend entirely on the mass of earth to withstand the water and in places have been rather unsafe in appearance for years. The average top width of the banks is estimated at 30 ft. and the slopes perhaps 1½ horizontal to 1 vertical. The river is diverted by a low dam about 3½ miles upstream and the lakes fed by means of an open canal or feeder built along the sidehill.

The Cuyahoga River rises near Burton and flows south a distance of about 40 miles, through the villages of Kent and Cuyahoga Falls, to the northern limits of Akron, where it turns abruptly on itself and flows northerly to Lake Erie. Its watershed at Kent is 300 sq.mi., at Cuyahoga Falls 350 sq.mi. and but little more until joined by the Little Cuyahoga at Akron, with its 50 sq.mi. of watershed already mentioned. The Cuyahoga is remarkable for the abrupt drops in its profile at certain points, notably at Cuyahoga Falls, where in two miles the fall is about 200 ft. Many small plants have utilized its power, the following dams having been built: Kent, fall 20 ft.; Monroe Falls, about 9 ft.; Cuyahoga Falls, six dams with falls [not heights of dams—Ed.] of 12, 10, 18, 18, 14 and 100 ft., respectively. The last is the new reinforced-concrete dam of the Northern Ohio Traction & Light Co., the actual height of which is about 50 ft., the remaining fall being in the natural bed of the river before reaching the power house.

With streams all at normal stage, 1.85 in. of rain fell on Sunday, Mar. 23, followed by 4.75 in. on Monday. On Tuesday, Wednesday and Thursday 3.05 in. more fell, making a total of 9.65 in. in about four days. The streams rose rapidly on Monday and reached their maximum stage on Tuesday. The principal damage was done by the Little Cuyahoga and the Ohio Canal. Along the Cuyahoga two of the small dams at Cuyahoga Falls were swept out and a number of bridges carried away, but no loss of life or heavy property damage has been reported.

Damage along the Little Cuyahoga

The Little Cuyahoga, discharging a volume roughly estimated at about 3000 cu.ft. per sec., found the water-

way through East Akron insufficient, and leaving the channel it poured through the city streets and the right-of-way of the Baltimore & Ohio R.R. to a depth of several feet, flooding the lower floor of the Goodyear Tire & Rubber plant, the Robinson Clay Products Co. and many smaller works. The power equipment and storerooms of the Goodyear Co. were flooded, causing a loss variously estimated at from $50,000 to $100,000. The roadbed of the Baltimore & Ohio R.R. was washed out down to bedrock for several hundred feet and a new channel cut longitudinally through Case Ave., where about 15 houses were demolished.

Farther down the valley the tracks of the Baltimore & Ohio were undermined and about 15 or 20 loaded freight cars tipped over the bank. The grounds of the Summit County Fair Association were badly cut up.

Elizabeth Park, one of the city playgrounds, fitted up during the past year, was practically demolished, with a loss of about $12,000. Below this point the havoc in Case Ave. was duplicated, and many houses destroyed.

The plate girder bridge at Howard St., connecting the northern part of the city with the business portion, was badly damaged but was one of the few bridges which stood. This bridge is about 75-ft. span, the girders being supported by piers 20 ft. from each abutment. The piers and abutments will probably have to be rebuilt. A concrete arch bridge of about 40-ft. span at Cuyahoga St. was entirely swept away.

FIG. 2. LOOKING UPSTREAM FROM POINT OPPOSITE GASHOLDER

FIG. 3. NEW CHANNEL CUT BY RIVER; EAST OF NORTH CASE AVE.

FIGS. 2 AND 3. VIEWS OF THE LITTLE CUYAHOGA RIVER AT AKRON, OHIO, BETWEEN 1 AND 2 P.M., MAR. 25, 1913
(At the point shown in Fig. 2 the water had been some 4 ft. higher before the view was taken.)

DAMAGE FROM THE CANAL STORAGE LAKES

The largest of the Portage Lakes, known as East Reservoir, cut through the bank at the point where the feeder from the Tuscarawas River enters. The bank here was almost entirely a natural formation, the artificial dikes remaining practically uninjured.

By quick and hard work state employees were able to dam the connection from the other lakes so that but about 2 ft. of water was lost from them, while East Reservoir was lowered 13 ft. Part of the water passed to the south, down the Tuscarawas, and the remainder to the north, down the Ohio Canal, where considerable damage was done to bridges and buildings built close to the canal level. The principal losses were the Alexander block, a three-story brick building, of which one end was entirely destroyed, the Cherry St. bridge, a plate-girder structure whose abutments were badly undermined and will have to be rebuilt, and a 5-ft. outfall sewer of reinforced concrete, lined with brick, under construction by the city of Akron in the old tow path, which was torn out for nearly 2000 ft. This was the main outfall sewer for the entire city and no other location is available for it. A serious problem presents itself in the reconstruction of this work. The tow-path embankment was washed away in several places, the total length destroyed being at least a mile.

Several of the canal lock gates were dynamited to prevent greater damage. This, together with the break in the reservoir and numerous failures of banks of feeders and of the canal, causes a renewal of the question as to the policy of the State of Ohio in regard to this canal system, now obsolete and used only for supplying water for industrial purposes.

EFFECT ON AKRON WATER-SUPPLY—A serious phase of the canal situation is its effect on the water-supply of Akron. The new source of supply, now under development, will not be ready for use for at least a year, and unless the reservoir is repaired in time to be filled before summer a disastrous water famine is certain in Akron, as the Tuscarawas is wholly inadequate during the dry months and the remaining storage is not sufficient to supply the demand. Work has been started on the necessary repairs and this danger is believed to be averted.

DAMAGE ALONG THE CUYAHOGA

The flow in the Cuyahoga at maximum stage is estimated, from the observed flow over the dams, at about 37 cu.ft. per sec. per sq.mi. of watershed. The old dam at Kent, the Monroe Falls dam, the Turner, Vaughn & Taylor dam at Cuyahoga Falls, and the new Northern Ohio Traction & Light Co. dam successfully withstood the flood. The first is a heavy stone-arched dam, the second a low masonry structure, the third a primitive timber crib of but 55 ft. spillway and the last a reinforced-concrete structure of the Ransome type, having a spillway 119 ft. long, depressed 5 ft. below the remainder of the structure and a total length of 449 ft. It has been recently described in several of the engineering journals.* The flow over this dam was 7.7 ft. on the spillway, and over the Turner, Vaughn & Taylor dam, 11.3 ft. Both are in sand-rock formation. The two dams which were destroyed were old timber structures of small value.

*A letter telling how this dam withstood a flood while under construction appeared in "Engineering News" for Nov. 14, 1912, p. 917. The height of the dam from stream bed to spillway top is there given as 52 ft.—Ed.

The Flood of March-April, 1913, on the Ohio River and Its Tributaries

By John C. Hoyt*

Disastrous floods may result from the following causes or combination of them: (1) Excessive rainfall; (2) the rapid melting of accumulated snow; (3) the failure of reservoirs; (4) the forming and breaking of ice jams; (5) the breaking of levees.

The recent floods on the Ohio and its tributaries, which at places have exceeded all those previously recorded, resulted primarily from excessive rains and at some points the damage was extended by the breaking of levees. The floods followed an exceptionally open winter during which frequent rains had completely saturated the ground and no snow or ice had accumulated.

The rain that started on the morning of Mar. 24 continued practically without interruption over the entire Ohio River basin until Mar. 27 and in a large area of maximum precipitation (Fig. 1), in western Ohio and eastern Indiana, the total precipitation exceeded 6 in. prior to Mar. 24. During this storm the total precipitation to Mar. 27 recorded at Bellefontaine, Ohio, was 11.16 in., at Marion, Ohio, 10.6 in., and at Bangerville, Ohio, 9.5 in. As shown in Tables I and II and on Fig. 1, the precipitation was about twice as great on the area drained by the northern tributaries of the Ohio as that drained by the southern tributaries.

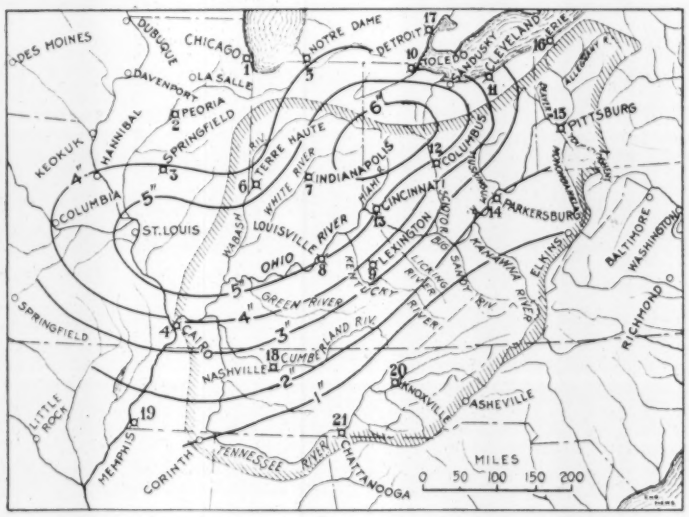

FIG. 1. PRECIPITATION IN OHIO AND INDIANA FLOOD AREA

(For the period from 8 p.m., Mar. 22, to 8 a.m., Mar. 26.)

Ohio River basin until Mar. 27 and in a large area of maximum precipitation (Fig. 1), in western Ohio and eastern Indiana, the total precipitation exceeded 6 in. prior to Mar. 24. During this storm the total precipitation to Mar. 27 recorded at Bellefontaine, Ohio, was 11.16 in., at Marion, Ohio, 10.6 in., and at Bangerville, Ohio, 9.5 in. As shown in Tables I and II and on Fig. 1, the precipitation was about twice as great on the area drained by the northern tributaries of the Ohio as that drained by the southern tributaries.

As the result of this widely extended and heavy precipitation, floods began on the various tributaries of the Ohio, starting on Mar. 24 and increasing in intensity until Mar. 27. The rise of the tributaries was followed by a rise of the Ohio proper which began on Mar. 27 and on Apr. 4 the crest of the flood had not passed Cairo.

The highest stream stages occurred in the area of maximum precipitation, on the tributaries entering the Ohio from the north. The Miami, which drains the larger portion of the area covered by the storm center, showed the greatest effect of the flood.

Although the loss of life and property was large in many places, it was probably greatest at Dayton, Ohio, which is located at the junction of the Miami River with its two principal tributaries—the Mad from the east and the Stillwater from the west (Fig. 2). The combined drainage area of these three streams is 2490 sq.mi., divided as follows: Miami River, 1160; Stillwater River, 650; and Mad River, 680.

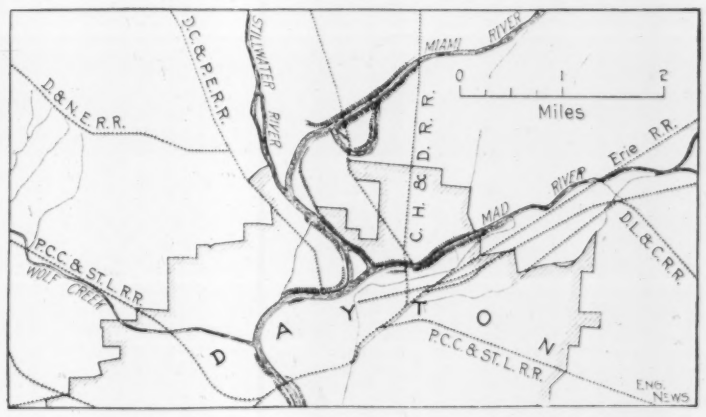

FIG. 2. CONFLUENCE OF RIVERS THAT CAUSED THE MARCH FLOODS AT DAYTON, OHIO

(From Topographical Map, U. S. Geological Survey—Surveys of 1903-4.)

The drainage area above Dayton comprises a comparatively flat, rolling country, in which the stream gradients are light and which is provided with no large artificial or natural storage reservoirs. For 15 miles above Dayton the Miami slopes about 1 ft. to the mile and flows through flats which vary in width from ½ to 1½ miles and are bordered by low bluffs. At Dayton these flats unite with those bordering the Mad and Stillwater, thus

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TABLE I. PRECIPITATION AT REGULAR WEATHER BUREAU STATIONS IN AND ADJACENT TO THE OHIO RIVER DRAINAGE BASIN, MARCH 20 TO APRIL 2, 1913

(Figures supplied by U. S. Weather Bureau. Values in inches for the 24 hours ending 8 a.m. on the respective dates.)

	Place	Mar. 20	Mar. 21	Mar. 22	Mar. 23	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Mar. 28	Mar. 29	Mar. 30	Mar. 31	Apr. 1	Apr. 2
1	Chicago	0.04	0.68	0.32	0.00	1.36	0.08	0.04	....	0.00	0.00	0.00	0.08	0.00	0.36
2	Peoria	0.16	....	0.00	0.22	....	0.06	0.01	0.08	0.00	0.00	0.00	0.10	0.00	0.00
3	Springfield	0.08	....	0.00	0.62	0.72	2.22	....	0.24	0.00	....	0.00	0.00	0.00	0.00
4	Cairo	0.26	....	0.00	0.00	0.06	1.56	2.72	0.26	0.00	0.00	0.00	0.00	0.00	0.00
5	Notre Dame	0.10	0.60	....	0.00	1.42	0.84	0.00	....	....	0.00	0.00	0.12	0.00	0.12
6	Terre Haute	0.02	....	0.00	0.46	0.98	2.66	....	0.38	....	0.00	0.00	0.00	0.00	0.00
7	Indianapolis	0.00	0.46	0.00	0.16	1.52	3.40	0.46	....	0.00	0.00	0.00	0.01	0.00	0.08
8	Louisville	0.01	0.56	0.02	0.00	0.00	0.16	5.10	0.68	0.00	0.00	0.00	0.00	0.00	0.00
9	Lexington	0.01	0.32	0.00	....	0.00	0.20	....	1.56	0.01	0.00	....	0.00	0.00	0.00
10	Toledo	0.00	0.46	0.00	0.00	2.44	2.68	0.34	0.68	0.02	0.00	0.00	0.34	0.00	0.00
11	Cleveland	0.00	0.01	0.02	0.00	1.96	2.88	1.26	0.98	0.10	0.00	0.00	0.18	0.00	0.00
12	Columbus	0.00	0.22	0.01	0.00	0.60	2.62	2.72	1.00	0.00	0.00	0.00	0.01	....	0.00
13	Cincinnati	0.01	0.38	0.00	0.00	0.40	2.24	1.75	0.80	0.00	0.00	0.00	0.04	0.00	0.00
14	Parkersburg	0.00	0.00	0.10	0.00	0.08	0.04	1.60	1.26	....	....	....	....	0.06	0.00
15	Pittsburgh	0.00	0.00	0.01	0.00	0.20	0.72	1.70	0.84	0.01	0.00	0.00	0.00	0.02	0.00
16	Erie	0.00	0.00	0.04	0.00	1.32	2.76	1.02	1.04	0.12	0.00	0.00	0.18	....	0.00
17	Detroit	0.01	0.64	0.02	0.00	1.30	1.26	0.24	0.60	0.06	0.00	0.00	....	0.00	0.00
18	Nashville	0.00	....	0.00	0.00	0.00	0.00	2.32	0.64	0.00	0.00	0.00	0.00	0.00	0.00
19	Memphis	0.00	....	0.00	0.00	0.08	0.00	1.60	0.18	0.00	0.00	0.00	0.00	0.00	0.00
20	Knoxville	0.00	0.74	0.02	0.00	0.00	0.00	0.24	2.16	0.00	0.00	0.10	0.08	0.00	0.00
21	Chattanooga	0.06	....	0.00	0.00	0.00	0.00	0.16	1.52	0.00	0.00	0.06	0.00	0.00	0.00

making a considerable area of low land which has been protected from overflow by a system of levees and through which Miami River flows in a double "S."

The excessive precipitation which occurred simultaneously over the area above Dayton not only rapidly filled the channels of the Miami and its tributaries but also flooded the adjacent flats. The system of levees at Dayton formed, as it were, a large storage reservoir for which the Miami served as a waste channel but a channel of insufficient capacity to keep the floods from overtopping and breaking through the levees. Such breaks admitted large quantities of water to the city, with the disastrous results that have been reported in the daily press. The highest flood previously recorded at Dayton was in 1866, when the river reached a stage of 21.3 ft. On Mar. 26 this stage was exceeded by nearly 8 ft., the height reached being about 29 ft.

No data are yet available from which to compute the maximum or total flow at Dayton. The rainfall records indicate that at least 800,000 acre-feet of water fell on the drainage area above Dayton during the storm that caused the flood. This amount of water represents an average flow of 100,000 sec.-ft. for four days. Low-water flows of less than 200 sec.-ft. have been recorded at Dayton.

As shown in Table III, the floods started in the westerly tributaries from the north, progressed eastward, and were much more intense on the northern tributaries which heretofore have never been especially important in causing floods on the Ohio.

Fortunately, the maximum stage occurred first on the lower tributaries, and, although these rapidly filled the channel of the main stream, sufficient time elapsed to permit the peak flow to pass before the water from the upper tributaries came in. For this reason the damage on the main stream was not so serious as it would have been if the storm had traveled downstream.

At Pittsburgh the Ohio did not rise as high as in January, as the Monongahela was not in heavy flood and extreme floods did not exist on the other streams which enter from the south. This relieved the situation on the main stream. The progress of the flood down the main stream is shown in the last column of Table III. New maximum high-water marks were established on the northern tributaries and at points along the main river. The stages on the southern tributaries were considerably below the previous maximums.

Table V gives the stages of the principal floods at Cincinnati since 1832.

Rating tables are available for various points along the Ohio River and on the more important tributaries, but owing to the interruption in transportation facilities sufficient gage heights have not been received at this

TABLE II. TOTAL PRECIPITATION, FROM SPECIAL OBSERVERS, FROM STARTING OF STORM TO MORNING OF DAY INDICATED

(Figures supplied by U. S. Weather Bureau)

		Inches
Piqua	March 24	6.68
Sidney	March 25	6.60
Fremont	March 25	6.12
Tiffin	March 25	6.72
Canton	March 25	3.22
Coshocton	March 25	2.90
Kings Mills	March 25	4.34
Oregonia	March 25	4.00
Zanesville	March 26	5.16
Wooster	March 26	9.00
Toboso	March 26	6.34
Upper Sandusky	March 26	8.44
Circleville	March 27	6.46
Bangerville	March 27	9.50
Bellefontaine	March 27	11.16
Marion	March 27	10.60

TABLE III. GAGE HEIGHTS FOR PRINCIPAL FLOODS OF OHIO AND TRIBUTARY RIVERS

(Figures from U. S. Weather Bureau. All elevations in feet.)

River	Place	Drainage area, sq.mi.	Danger line	Max. (date)	Feb. 1883	Feb. 1884	Mar. 1890	Feb. 1897	Mar. 1898	Jan. Mar. 1907		Mar. 1912	1913 Date	1913 Stage	1913 Difference from previous maximum
Ohio	Pittsburgh, Penn.	17,000	22	35.5 (1907)	26.8	31.9	22.5	28.9	28.5	23.3	35.5	28.1	Mar. 28	30.4	—5.1
Ohio	Wheeling, W. Va.	25,200	36	53.1 (1884)	35.5	53.1	32.5	37.0	43.9	36.1	50.1	38.4	Mar. 28	51.1	—2.0
Ohio	Marietta, Ohio	32,400	25	52.0 (1884)	43.7	52.0	33.5	36.0	....	....	....	....	.....	....	
Ohio	Parkersburg, W. Va.	37,200	36	53.9 (1884)	....	53.9	35.0	37.5	47.8	39.9	51.4	36.7	Mar. 28	58.9	+5.0
Ohio	Point Pleasant, W. Va.	51,500	39	60.0 (1884)	....	60.0	47.9	52.3	51.2	52.0	54.8	43.0	.....	....	
Ohio	Huntington, W. Va.	58,600	50	64.8 (1884)	....	64.8	....	....	....	57.8	58.4	48.1	Mar. 31	66.4	+1.6
Ohio	Catlettsburg, Ky.	59,300	50	72.0 (1884)	....	72.0	52.6	58.5	56.0	60.0	60.4	49.4	.....	....	
Ohio	Portsmouth, Ohio	66,300	50	66.3 (1884)	....	66.3	55.5	59.0	57.3	60.9	60.8	51.0	.....	....	
Ohio	Cincinnati, Ohio	73,900	50	71.1 (1884)	66.3	71.1	59.1	61.1	61.4	65.2	62.1	53.4	Apr. 1	69.8	—1.3
Ohio	Louisville, Ky.	87,200	28	46.7 (1884)	43.8	46.7	35.3	35.4	36.3	41.4	36.0	28.7	Apr. 2	45.0	—1.7
Ohio	Evansville, Ind.	102,000	35	48.3 (1884)	47.8	48.8	44.4	43.6	43.7	46.2	43.8	42.6	Apr. 5	48.3	—0.5
Ohio	Paducah, Ky.	203,800	43	54.2 (1884)	50.7	54.2	47.2	43.7	47.3	45.7	42.3	49.9	.....	....	
Ohio	Cairo, Ill.	204,300	45	54.0 (1912)	52.2	....	48.7	51.6	49.8	50.4	46.2	54.0	Apr. 5	54.7a	+0.7
(North Ohio) Muskingum	Zanesville, Ohio	6,470	25	36.8 (1898)	....	....	14.4	....	36.8	25.3	30.4	22.8	.....	....	
Scioto	Columbus, Ohio	1,570	17	21.3 (1898)	....	....	....	....	21.3	17.3	19.0	16.0	Mar. 25	22.9	+1.6
Miami	Dayton, Ohio	2,490	18	21.3 (1866)	....	....	....	16.3	18.3	12.0	15.2	14.0	Mar. 26	29.0	+7.7
Wabash	Mount Carmel, Ill.	26,300	15	28.3 (1875)	....	....	22.0	26.4	27.0	24.5	23.0	23.2	Mar. 30	31.0	+2.7
(South Ohio) Kanawha	Charleston, W. Va.	9,200	30	46.9 (1861)	....	....	30.9	41.0	19.5	29.3	20.9	18.5	Mar. 28	33.0	—13.9
Big Sandy	Louisa, Ky.	3,630	....	50.0 (1875)	....	45.3	40.0	46.6	....	....	....	....	Mar. 28	44.8	—5.2
Licking	Falmouth, Ky.	2,900	25	38.0 (1854)	....	....	24.7	27.0	17.6	28.5	28.1	22.3	.....	....	
Kentucky	Frankfort, Ky.	5,140	31	44.0 (1878)	42.0	....	31.0	....	....	29.6	20.6	25.6	Mar. 28	38.3	—5.7
Cumberland	Nashville, Tenn.	11,600	40	55.3 (1882)	41.6	47.2	40.9	37.5	24.0	28.2	38.9	46.5	.....	....	
Cumberland	Clarksville, Tenn.	13,400	43	60.6 (1882)	....	....	....	....	....	38.8	36.2	53.6	Mar. 28–29	50.5	—10.1
Tennessee	Johnsonville, Tenn.	33,700	25	48.0 (1882)	29.0	44.3	28.0	48.0	21.7	12.5	22.5	35.4	.....	....	

a Crest not passed.

time from which the quantity of water flowing during the present flood can be computed.

Preliminary estimates show a maximum flow at Cincinnati of 676,000 sec.ft., or an average for the whole drainage area of 9 sec.-ft. per sq.mi. For the 10-day period from Mar. 26 to Apr. 4, about 12,100 acre-feet passed Cincinnati.

Excessive rainfall will inevitably produce floods in

TABLE IV. STAGES OHIO RIVER AND TRIBUTARIES, MARCH 23 TO PAST CREST OF FLOOD

(Readings at 8 a.m. Figures from U. S. Weather Bureau)

	Ohio River Stages					
Date	Pittsburgh	Parkersburg	Cincinnati	Louisville	Evansville	Cairo
Danger line.	22.0	36.0	50.0	28.0	35.0	45.0
March 23..	4.8	10.0	24.7	10.8	28.3	39.9
March 24..	4.5	9.5	22.6	10.0	....	40.3
March 25..	7.8	10.0	20.3	11.4	....	....
March 26..	20.1	22.1	50.3	22.5	....	43.5
March 27..	28.0	43.0	57.2	33.6	36.6	45.5
March 28..	30.4	54.9*	62.6	38.4	40.4	47.4
March 29..	24.8	58.7	66.0	41.1	....	49.1
March 30..	17.8	57.9	67.9	42.1	44.4	50.6
March 31..	13.7	53.8	69.2	43.7	....	52.0
April 1.....	11.4	47.5	69.8	44.7	46.4	53.2
April 2.....	9.6	38.1	69.5	45.0	47.2	54.1
April 3.....	8.6	27.2	68.0	44.6	47.8	54.5
April 4.....	7.9	19.5	66.0	43.8	48.2	54.7
April 5.....	7.1	16.5	63.3	42.9	48.3	54.7

	Stages of Tributaries									
Date	Mt. Carmel on Wabash	Dayton on Miami	Columbus on Scioto	Beaver Falls, Penn., on Beaver	Freeport, Penn., on Allegheny	Fairmont, W. Va., on Monongahela	Charleston, W. Va., on Kanawha	Frankfort, Ky., on Kentucky	Clarksville, Tenn., on Cumberland	Chattanooga, Tenn., on Tennessee
Danger Line	15.0	18.0	17.0	11.0	20.0	25.0	30.0	31.0	43.0	33.0
March 22.....	11.9	3.0	4.4	4.6	6.5	15.1	6.0	8.6	29.7	12.9
March 23.....	13.4	3.0	4.8	4.4	6.2	15.0	5.9	8.7	24.4	12.9
March 24.....	13.6	7.0	6.2	6.6	5.9	14.9	5.7	8.5	20.6	12.3
March 25.....	19.8†	29.0†	22.9†	13.2	16.2	14.8	5.5	8.5	20.1	11.2
March 26.....	21.4	28.1‡	20.9	16.7	26.4	14.8	5.5	15.8	31.6	10.1
March 27.....	23.0	22.2‡	19.7	17.4	32.2†	23.6†	10.2	35.2	47.3	13.3
March 28.....	25.8†	15.7‡	17.4	15.1	29.5	22.4	33.0	38.3	50.5	25.4
March 29.....	29.5†	11.6	14.7	12.0	23.5	19.1	30.0	37.5	50.5	31.2
March 30.....	31.0	9.1	12.0	8.9	19.0	16.9	21.0	37.2	49.6	33.3†
March 31.....	30.2	7.3	9.6	6.8	15.4	16.4	19.0	35.1	49.3	32.9

* Maximum at 8 p.m., 58.9. † Maximum occurring before or after 8 a.m. reading. ‡ Calculated from measurements made at north end of Dayton View Bridge.

which the improvements that follow the progress of civilization must be recognized as important factors. The cutting away of forests and the artificial drainage systems which accompany agricultural and municipal development create conditions favorable for quick runoff. The building of bridges, railroad embankments, levees, and other structures has in many localities by encroaching on

TABLE V. FLOOD STAGES OF OHIO RIVER AT CINCINNATI, OHIO

(Danger line, 50 ft. on gage; maximum 71.1, February, 1884; lowest stage, 1.9 September 17-19, 1881. Figures from U. S. Weather Bureau.)

Year	Date	Stage, feet	Year	Date	Stage, feet
1832	Feb. 18	64.3	1890	March 26	59.2
1847	Dec. 17	63.6	1891	Feb. 25	57.3
1862	Jan. 24	57.3	1893	Feb. 20	54.9
1865	March 7	56.3	1897	Feb. 26	61.2
1867	March 14	55.8	1898	March 29	61.4
1870	Jan. 19	55.3	1899	March 8	57.2
1875	Aug. 6	55.3	1901	April 27	59.7
1876	Jan. 29	51.8	1902	March 5	50.9
1877	Jan. 20	53.8	1903	March 5	52.3
1880	Feb. 17	53.2	1905	March 13	48.3
1881	Feb. 16	50.6	1907	Jan. 21	65.2
1882	Feb. 21	58.6	1908	April 4	55.9
1883	Feb. 15	66.3	1909	Feb. 28	54.6
1884	Feb. 14	71.1	1910	March 7	51.8
1886	April 9	55.8	1912	March 27	53.4
1887	Feb. 5	56.3	1913	April 1	69.8

river channels materially reduced the carrying capacity of streams, choking the channel at flood stages and backing the water over adjacent lands.

The extent to which the damage caused by the flood would have been abated by a comprehensive system of protection is now a matter of intense public interest. Many of the press reports of the flood have stated that the loss would have been largely reduced by reservoirs, proper forestation, levees, channel improvements, and other works. All these works are recognized aids in flood protection, but their effectiveness on any river system can be determined only by careful studies of all conditions, and little reliance should be placed on broad statements in regard to flood control.

The topography of the drainage area north of the Ohio River is of a type which does not, in general, afford any large possibilities for storage. If there are no large reservoir sites on the northern tributaries of the Ohio, relief by means of storage is impossible on these streams and flood protection must be gained primarily by levees and channel improvement. Preliminary studies of the basins drained by the southern tributaries indicate that there are many reservoir sites in these basins sufficiently large to afford storage for flood waters.

The maximum stages on the Ohio in the present flood were caused by the combination of the exceptionally excessive floods from the northern tributaries and the moderate floods from the southern tributaries. Proper storage on the southern tributaries might, therefore, have held back sufficient water to have materially reduced the crest height on the main stream. The effect of such storage can be determined only by a comprehensive study which should be made in connection with a study of possible river improvements.

Another question which must be considered in the flood problem is the factor of risk. Shall we provide for the average flood, or shall we provide for the exceptional flood, knowing that the increased cost of construction, maintenance, and operation of works needed to provide for extreme conditions will be offset by the reduction in loss of life and in the damage resulting from the excessive floods? This phase of the subject is always in the mind of the engineer who designs river improvement works, but does not always appeal to those who control the funds.

As already intimated, the combination of conditions that caused the recent flood, if reversed on the drainage area, would probably have produced much more serious results. That such a flood may occur is not improbable. The results of such a disaster can be estimated by extending the damage and loss in the congested area of the present flood to the lowlands of the entire basin and probably to the lower Mississippi.

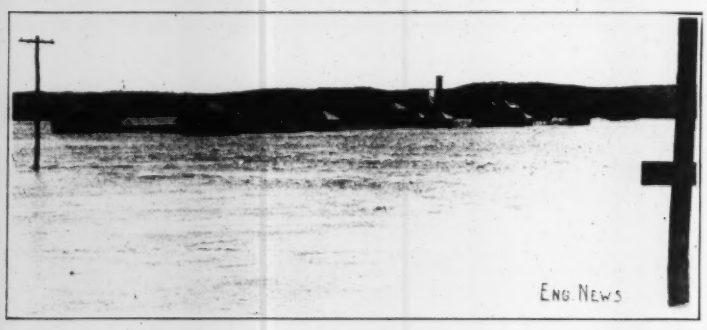
If such a flood should occur on the Ohio, in conjunction with the floods on the upper Mississipi and Missouri (which, of course, is possible since excessive rains in this locality are not peculiar to any season), the damage that would result on the lower Mississippi River would probably produce a calamity unprecedented in the history of this or any other country. With this possibility confronting the country, it is the opinion of all who have studied the situation that there should be no further delay in establishing a complete system of river control, in which there shall be systematic coöperation between the National Government and the States and local interests.

The Flooding of the Albany Filtration Plant and Previous High Floods at Albany, N. Y.

By Wallace Greenalch*

The recent flood in the Hudson River first assumed dangerous proportions on the morning of Thursday, Mar. 27, when at 8 a.m. the water reached an elevation of 17 ft. above mean low water. At 2 p.m. the water reached Elev. 18 and at midnight reached Elev. 21, the level of the top of the slow sand filtration plant. The water then rose quickly, reaching Elev. 22 at 3 a.m. and continued to rise until 1 p.m. Friday, Mar. 28, when it reached its highest level at Elev. 23.1. The water then slowly receded and fell below Elev. 21 about 6 a.m., Saturday, Mar. 29.

Precautions were hurriedly taken on Thursday to keep out as much of the flood as possible by barricading the doors of the pumping station and preliminary filters which were above Elev. 21. The doors of the regulator houses in the slow sand filter court were also braced from the inside and the cracks calked with oakum to prevent the entrance of raw water into the pure-water effluents from the filters and into the pure-water reservoir should the water get over the tops of the filters and into the



Filtration Plant at Albany, N. Y., under Water on Mar. 28, 1913

(Taken from Erie Canal Lock, looking east. Water 2 ft. over top of covering of slow sand filters and over sedimentation basin.)

courtyard, which is at about Elev. 15. A temporary embankment of sods and dirt about 2 ft. high was hurriedly thrown up around the courtyard. This embankment kept the water out of the court for a few hours and would probably have been effective had the water not risen more than 1 ft. above the tops of the filters. As it happened, the water broke through the embankment and filled the courtyard at about 4 a.m., Friday morning.

As the high-service reservoir has a capacity of only 7,000,000 gal., about half of which can be drawn upon for about six hours without affecting the supply of buildings on the upper levels, and as there was grave danger of fires occurring in the flooded districts of the city, it was deemed necessary to keep up the reservoirs by pumping, even though the water might contain some raw water which would find its way into the filtered water from the slow sand filters which would continue to operate.

After the flood receded below Elev. 21, it was found that the door of the regulator house to Filter 7 had been broken in by the water pressure which allowed the raw water to enter the pure-water reservoir. The cover of the manhole over the pure-water reservoir was also blown off by the air confined by the rising water and made another entrance for the raw water.

When the flood receded to below Elev. 21 the water fell in the court and by 10 a.m., Saturday, the filters were delivering nothing but filtered water to the city after having been flooded about 30 hours.

The hypochlorite plant, which was put out of commission when the flood entered the court, was placed in operation Saturday afternoon with an increased dose of hypochlorite in the filtered water. On Friday night, when danger of overflowing was imminent, the newspapers were notified to warn the people to boil all water before drinking it and the notices appeared in the papers Saturday morning before any raw water reached the city. The city water was more or less turbid Saturday but samples taken on that day showed no B.coli present in 10 c.c. of water.

Samples of water taken Monday, Mar. 31, showed coli present in the high-service reservoir, so the water was at once treated with hypochlorite suspended in bags from a boat on the reservoir. This method seems to have been effective as samples taken on Apr. 3 showed no evidence of coli in the reservoir. The water mains have also been flushed by opening hydrants. In the flooded section of the city a large amount of water was used for flushing the streeets as soon as the heaviest accumulation was removed by the street cleaning force.

Water is supplied to the entire city from two services by direct pumpage of filtered water into the systems, with reliefs to the reservoirs. The low service may also be supplied by gravity from Rensselaer Lake through a brick conduit four miles long. This water was immediately turned into the low-service reservoir at the rate of about 7,000,000 gal. per 24 hours so as to reduce the pumpage of contaminated water into the low service.

The deposit from the flood was not enough to interfere with the slow sand filters, the operation of which was promptly resumed as soon as the water passed out of the court. The filters, of course, are now (Apr. 5) being scraped, one at a time, in the usual manner, as soon as the loss of head shows that they require it. The first water filtered was slightly turbid but soon cleared, while the bacteria were reduced by an extra dose of hypochlorite of lime. The dilution of the raw water was so great during the period the plant was flooded that no danger from typhoid is expected.

Although the water rose to a height of 13 ft. above the floor of the pumping station (Elev. 10), the barricading of the doors (at Elev. 21) kept out the water so that the boilers and pumps were kept in operation pumping out water which leaked into the station.

The following is a list of the principal flood heights above mean low water at Albany, from the records of the United States Engineer's office in this city:

	Feet		Feet
Jan. 27, 1839.....	17.78	May 5, 1893.....	16.12
May 15, 1846.....	18.27	Apr. 10, 1895.....	15.96
Feb. 9, 1857.....	21.25	Mar. 1, 1896.....	17.78
Jan. 11, 1869.....	18.00	Mar. 13, 1898.....	13.30
Apr. 22, 1869.....	19.00	Mar. 6, 1899.....	12.45
Oct. 4-5, 1869.....	18.52	Feb. 14, 1900.....	19.96
Feb. 16, 1876.....	14.00	Dec. 12, 1901.....	13.58
Feb. 14, 1886.....	17.89	Mar. 2, 1902.....	18.50
Apr. 12, 1887.....	15.00	Mar. 2, 1903.....	16.32
Mar. 26, 1893.....	18.43	Mar. 28, 1913.....	21.00

The flood in the river was no doubt due to the large rainfall, with possibly some melted snow on the upper Hudson and Mohawk rivers. The newspapers on Thurs-

*Commissioner of Public Works, Albany, N. Y.

day reported a rainfall of 5.19 in. at Glens Falls and 4.35 in. at Corinth. The flood came to us very unexpectedly as only 1.75 in. of rain had fallen at Albany, which was not sufficient to produce a freshet.

At the filtration plant the water on Mar. 28, 1913, reached Elev. 23.1, while opposite the center of the city two miles south of the filtration plant the U. S. Engineer's Office reports Elev. 21 and the U. S. Weather Bureau reports Elev. 22.4. The last two datum levels are not the same, there being a difference of 1.35 ft. between them. On Feb. 14, 1900, the water at the filtration plant reached Elev. 20.5, which was 6 in. below the top of the filters, while the last (1913) flood was 25 in. above the top of the filters. The newspapers reported that the last flood exceeded the flood of 1857 by 2½ ft., but investigation shows that the 1857 flood was higher by from ½ to 3 in.

[It might be noted that the present freshet appears to have resulted solely from a coincidence of heavy rainwater flow from the various tributaries of the Hudson and was affected little, if any, by melting snow. Most of the previous high-water stages were partly brought about by melting snow.—Ed.]

Measures will be taken during the coming summer to prevent a repetition of the last experience by building protection walls or embankments at the filtration plant.

The only damage done by the flood besides that mentioned was the breaking of several doors on the slow sand filters and the depositing of mud in the court and elsewhere.

[The following additional information on the use of hypochlorite at Albany has been received from a correspondent.—Ed.]

Hypochlorite has been used at the Albany filtration plant, as a finishing process, since 1909; continuously since 1911, and except for certain periods in summer from 1909 to 1911, when it was thought that double filtration was sufficient. A temporary hypochlorite plant was fitted up for use when the regular plant was flooded, and the agent was used in extra quantities both then and after the regular plant was again put in use.

In applying the hypochlorite to the Prospect Reservoir, it was found necessary to punch holes in the bags containing the bleaching powder and to move the bags vigorously in order to liberate the powder. Apparently the powder was well distributed through the water in this way. Bacterial counts of water samples indicated that the available chlorine was fairly well liberated before the powder reached the bottom of the reservoir. Bacterial counts made by the State Department of Health showed B. coli present in 0.1 c.c. of water before treatment but absent in two out of three 10-c.c. samples.

On April 5 hypochlorite was being applied to the reservoir a second time and arrangements were being made to eliminate all possibly polluted water from the distributing pipes by flushing. The State Department of Health is coöperating in the measures being taken to safeguard the Albany water-supply.

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The Famous Concrete Y-Bridge at Zanesville, Ohio, was not destroyed by the flood or dynamited to clear the channel, as the first reports from Zanesville stated. It is reported in good condition except for the parapets, which were badly battered by drift. The railway bridges above and below the Y-bridge were carried away.

The Floods in the Ohio and Mississippi Rivers

During the past week, the flood wave in the Ohio River, resulting from the heavy storm on the northern tributaries of the Ohio during the last week in March, passed down the river from Pittsburgh to Cairo, causing at some points the highest stage of water that has ever been recorded. Very few lives were lost, as cities along the Ohio River are accustomed to high-flood stages and the rise of the river was gradual, giving plenty of warning in advance. The amount of property destruction and resulting suffering, however, was enormous.

On Sunday, Mar. 30, the Ohio River was falling from Pittsburgh down stream about as far as Parkersburg, W. Va., where the height reached was 22 ft. above the flood stage, and at all points below the river was rising, the stage at Cincinnati being 67.9 ft. and at Cairo 50.6 ft. The maximum stage reached at Cincinnati was 69.8 ft. at 8 a.m. on Tuesday, Apr. 1. This is the highest stage ever reached in that city with the exception of the flood of 1884, when a stage about 2 ft. higher was recorded. The crest of the 1884 flood, however, was a very short time in passing the city with a rapid rise and fall on each side. In the present flood the crest of the flood wave was very flat, the gage reading 67.9 on Sunday, Mar. 30, and 68 ft. on Thursday, Apr. 3. The fall since then has been rapid, but a very high stage of water prevailed also during the previous week, due to the heavy flood coming down the Miami and the Scioto in advance of the floods from the upper tributaries. It appears certain, therefore, that the volume of flood water discharged by the Ohio as a result of the recent storm is greater than that in any flood ever recorded.

On Wednesday, Apr. 2, the crest of the flood was at Louisville, where a stage of 45 ft. was reached, 17 ft. above the flood level. At Cairo on the same date the gage stood at 54.1. On Friday the crest had moved down the river to Evansville and a stage of 54.7 ft. was reached at Cairo, at which point the gage remained about stationary for several days with slight variations, due to the breakage of minor levees above Cairo and the flooding of lowlands, giving some relief to the flood height.

The above data are taken from the official weather maps issued by the Weather Bureau of the Department of Agriculture, which on Friday, Apr. 4, issued a special flood bulletin predicting maximum stages for points on the Mississippi from Memphis to New Orleans. These maximum stages are nearly identical with the maximum heights reached in the flood of 1912, and are based on the supposition that the levees along the lower Mississippi continue to hold water, and also on the occurrence of no storms along the tributaries of the lower Mississippi which will add materially to the height of the flood wave. The maximum stage reached at Cairo is about 1 ft. higher than the highest record of the 1912 flood, and, as noted above, the crest of the flood wave was very flat, making the test of the levees to resist wave and current action very severe. The Weather Bureau predicted that the crest of the flood will reach Vicksburg, Miss., by Apr. 23 or 24, and New Orleans between Apr. 24 and 30. At the latter point a crest stage of about 21.3 ft. was predicted in the special bulletin dated Apr. 4. In a bulletin issued four days later, by the Bureau, maximum flood stages slightly higher were predicted.

By the Falling of a Scaffold a foreman and three laborers were killed at the Miraflores locks, Panama Canal, on Apr. 3.

The Derailment of a Freight Train on the Southern Ry., near Hickory, N. C., caused the deaths of three railway employees on Mar. 31.

A Butting Collision between a freight and a passenger train on the Western Maryland Ry., at Bidwell, Penn., on Mar. 30, resulted in the deaths of two railway employees and serious injuries to two passengers.

A Butting Collision between two passenger trains on the Chicago, Burlington & Quincy R.R., occurred Apr. 3, near Sheridan, Wyo. A passenger and an express messenger were killed and eight other persons were seriously injured. According to press dispatches the accident was due to the failure of the engineer of the eastbound train to follow his orders to take a siding at Wakely, Wyo., and wait for the westbound train to pass.

Accidents to Railway Employees in the State of Georgia for the year 1912, showed an increase of 100% over the number of accidents in 1911, according to a recent report of the Georgia State Railroad Commission. On the steam railways of the state 2384 employees were injured and 74 employees were killed in 1912.

A Locomotive Crashed Through the Station Building at Hoytville, Ohio, on the Baltimore & Ohio R.R., on Apr. 5. The locomotive was attached to an eastbound passenger train and ran into an open switch at high speed. The locomotive was torn loose from the rest of the train and crashed into the wood station building, killing the locomotive fireman and a man who was in the station waiting-room.

A Dynamite Explosion killed four laborers and fatally injured a fifth, near Sherbrooke, Que., on Mar. 26. The men were engaged in blasting ice in the Legendre River for a log drive. The explosion occurred while they were attempting to thaw some dynamite in pails of hot water.
News Note N.R.

Contact of a Steel Tape with the High-Tension Wires used to carry the current for operating the electric locomotives on the New York, New Haven & Hartford R.R., caused the death of Edward J. Fogarty, a civil engineering student of Yale University, on Apr. 2. The accident occurred near New Rochelle, N. Y. Mr. Fogarty and a schoolmate had been engaged by an attorney of New Haven, Conn., to make measurements to be used as evidence in a damage suit against the railway on account of the death of a locomotive runner, who was killed by an electric shock. Mr. Fogarty and his companion were measuring the height of the charged wires above the rail; he was standing on the stone abutment of a bridge holding a steel tape, when the tape was blown against the charged wire by the wind. The shock caused him to fall headforemost to the tracks, fracturing his skull. His companion, who was holding the lower end of the tape, was severely but not fatally burned.

The Cape Cod Canal builders have applied for another extension of time. The canal was to have been completed in June, 1912, but an extension of two years was granted previous to that time. A petition filed with the Massachusetts state legislature on Apr. 4, asks for 18 months more in which to complete the work. The petition is filed in the name of the Boston, Cape Cod & New York Canal Co., and recites that many unforseen physical conditions have been encountered to make the construction work slow. The subcontractors who have been unable to fulfill their contracts with the Cape Cod Canal Construction Co., have been released from further responsibility, and new arrangements have been made for the prosecution of the work. In making the new subcontracts the Canal company was unable to secure any builders who would agree to complete the work on the date set by the previous agreements, June 3, 1914. The total cost of the work is estimated at $12,000,000; and stocks and bonds have been issued to date to the amount of $6,675,000. Capital for construction work can be raised by the sale of stock and bonds only in installments as the work progresses, subject to the approval of the Massachusetts Board of Harbor and Land Commissioners and the State Railroad Commission. There is now pending before these Commissions an application to issue about $4,800,000 more in stock and bonds. It is reported that the canal is 70% completed at the present time.

The Center St. Loop Subway, in New York City, is nearly completed, and will soon be operated by the Brooklyn Rapid Transit Co., trains running over the Williamsburgh Bridge from the Broadway (Brooklyn) elevated railway. The Loop Subway, though the larger part was finished several years ago, has been idle because the terminal station under the Municipal Building had to wait for the construction of that building. This station is now nearly completed; when in operation it will be used as a four-track stub terminal until connection is made to the Brooklyn Bridge or south by subway through Nassau St. to a new East River tunnel at South Ferry. Track is to be laid in the Loop Subway soon. It will consist of 80-lb. rail on sawn yellow-pine ties in stone ballast, and 80-lb. third-rail. All rail is to be of 100-lb. section ultimately, 80-lb. rail from stock being put in now to save time. Two sets of crossovers and two interlocking machines for them are involved.

Tunneling on the Necaxa Power Plant, Mexico, Extension Work.—"Eng. News," Mar. 6, 1913, p. 486, is going on very much more rapidly than there stated. The engineers of the tunnel work, Jacobs & Davies, have called attention to the fact that our figures (intended as feet per week, but printed as feet per month) were in error, and quote the following figures for recent rate of advance in Tunnel No. 1, the lowest and longest of the series: January, 1913, heading advance, 636 ft.; February heading advance, 496 ft.; March heading advance, 746.2 ft. This represents two faces.

This tunnel is 3473.8 m. (11,394 ft.) long. It is in soft ground, and the whole length of the headings has been fully timbered. Concrete lining is put in close behind the bench excavation. Work is prosecuted from both ends. The outlet heading is now 1290 m. (4231 ft.) in from the portal, having advanced 400 ft. in March; the inlet heading is 1802.3 m. (5911 ft.) in, having advanced 346 ft. in March. The total advance of headings is therefore 10,142 ft. (Mar. 31, 1913), leaving 1252 ft. to be penetrated.

The Protection of New Castle, Penn., against Floods from Neshannock Creek has been reported on by R. Winthrop Pratt, consulting engineer, of Cleveland, Ohio. The flood of Mar. 25, 1913, did considerable damage in the city and on Apr. 3 Mr. Pratt submitted his report. The following statement on the subject has been supplied to us by R. F. McDowell, assistant engineer to Mr. Pratt:

New Castle, having a population of about 40,000, is located in the valleys of the Shenango River and Neshannock Creek, just above the confluence of these streams. The Shenango and Mahoning rivers unite to form the Beaver River at a point about four miles below the city.

The watershed of the Neshannock Creek, which covers about 250 sq.mi., has a hilly topography and the bed of the stream has a steep slope. The runoff is hence rapid and at times of excessive rains the banks are overflowed within the city.

The immediate causes of damage from floods at New Castle are the deposits in the stream bed; the low elevation of the banks in the upper part of the city; and the obstruction to flow caused by several bridges and a dam within the city limits. Also the backwater from floods in the Shenango River sometimes passes up the Neshannock Creek channel and overflows the low banks in the lower part of the city.

The general plans for protection of the city, recommended in Mr. Pratt's report, include the dredging of the existing deposits in the bed of the stream; widening the channel in places; building reinforced-concrete retaining walls and earth-fill dikes to elevations above possible future flood levels; removing the Rosena dam; improving the channel in the vicinity of the East Washington St. bridge by modifying the approaches to the same, placing a concrete floor in the bed of the creek; and raising or lengthening the railroad bridges near the mouth of the creek.

PERSONALS

Mr. J. Frank Bowen, of Hartford, Conn., has been appointed City Engineer of Manchester, Conn.

Mr. H. P. Parsons, formerly Assistant Engineer of Ottawa, Ont., has been appointed City Engineer of Peterborough, Ont., at a salary of $2500 per annum.

Mr. Charles M. Schwab has resigned as President of the Bethlehem Steel Co. to become Chairman of the Board of Directors. He is succeeded as President by Mr. E. G. Grace.

Mr. A. D. Case has been appointed Engineer of Structures of the Boston & Albany R.R., succeeding Mr. W. F. Steffens, Assoc. M. Am. Soc. C. E., resigned, as noted in our issue of last week.

Mr. W. J. McLean, formerly Master Mechanic of the Duluth, Winnipeg & Pacific Ry., at West Duluth, Minn., has been appointed Master Mechanic of the Kettle Valley Ry., at Penticton, B. C.

Mr. J. A. Loughlin has become associated with Mr. H. DeW. Rapalje, Assoc. M. Am. Soc. C. E., for the general practice of civil engineering under the firm name of Rapalje & Loughlin, with offices in Wilmington, N. C.

Mr. Henry Jungerman, formerly with the motive power and inspection department of the Union Pacific and Southern Pacific Rys., has been appointed Railway Representative of Tate-Jones & Co., Inc., of Pittsburgh, Penn.

Mr. Lewis W. Baldwin, Engineer of Maintenance-of-way of the Illinois Central R.R., at Chicago, Ill., has been appointed Superintendent of the Kentucky division, at Louisville, Ky., succeeding Mr. A. H. Egan, promoted, as noted elsewhere.

Mr. Marco Johnson, Assoc. M. Am. Soc. C. E., Assistant Engineer of Bridges of the Illinois Central R.R., has been promoted to be Engineer of Bridges and Buildings, at Chicago, Ill., succeeding Mr. Fred L. Thompson, promoted, as noted elsewhere.

Mr. Daniel J. Brumley, M. Am. Soc. C. E., formerly Engineer of Construction of the Illinois Central R.R., at Chicago, Ill., has been appointed Engineer of Maintenance-of-way, at Chicago, succeeding Mr. L. W. Baldwin, promoted, as noted elsewhere.

Mr. Mellis V. Ferguson, Assoc. M. Can. Soc. C. E., has resigned as City Engineer of Guelph, Ont., to accept the position of City Engineer of St. Thomas, Ont., at a salary of $2000 per annum. He is succeeded at Guelph by Assistant City Engineer Holland.

Mr. Fred L. Thompson, Engineer of Bridges and Buildings of the Illinois Central R.R., has been promoted to be Engineer of Construction, with headquarters at Chicago, Ill., succeeding Mr. D. J. Brumley, M. Am. Soc. C. E., promoted, as noted elsewhere.

Mr. George W. Berry, formerly General Superintendent of the Yazoo & Mississippi Valley R.R., at Memphis, Tenn., has been promoted to be Superintendent of Terminals of the Illinois Central R.R., at Chicago, Ill., succeeding Mr. James H. Brinkerhoff, resigned.

Mr. W. H. Breithaupt, M. Am. Soc. C. E., Consulting Engineer, Toronto, Ont., has associated with him Mr. Charles B. Kingsley, Assoc. M. Am. Soc. C. E., to continue the engineering practice of the late E. H. Keating and Mr. Breithaupt (Keating & Breithaupt).

Mr. H. M. Taylor, M. Am. Soc. C. E., Director of Construction of the National Rys. of Mexico, has resigned, and his former position has been abolished. The duties of the office will hereafter be assumed by the Chief Engineer of Construction, Mr. G. P. De Wolf.

Mr. E. R. Conant, recently Principal Assistant Engineer, United States Engineer Office, Savannah, Ga., has been appointed Chief Engineer of the City of Savannah, a position recently created which combines the former offices of City Engineer and Director of Public Works.

Mr. Alfred H. Egan, formerly Superintendent of the Illinois Central R.R., at Louisville, Ky., has been promoted to be General Superintendent of the Yazoo & Mississippi Valley R.R., with headquarters at Memphis, Tenn., succeeding Mr. George W. Berry, promoted as noted elsewhere.

Messrs. James A. Armstrong and Chester H. Prouty, for several years connected with the engineering department of the Union Sugar Co., Santa Barbara, Calif., have formed a partnership with offices in the Forsythe Bldg., Fresno, Calif., for the general practice of engineering, specializing in soils and irrigation work.

Mr. William E. Morris, former Assistant General Manager of the Chicago & Northwestern Ry., has been appointed General Manager of the Denver, Northwestern & Pacific Ry., at Denver, Colo. Mr. Morris was compelled to resign his position with the Chicago & Northwestern Ry. about a year ago, because of ill health.

Mr. E. Richards, formerly Superintendent of the St. Louis Southwestern Ry. of Texas, at Mt. Pleasant, Tex., has been appointed Superintendent of the St. Louis Southwestern Ry. at Pine Bluff, Ark., succeeding the late E. A. Peck. Mr. F. J. Hawn, formerly Superintendent of Transportation at Tyler, Tex., succeeds Mr. Richards at Mt. Pleasant.

Mr. William A. Nettleton, M. Am. Soc. M. E., former General Superintendent of Motive Power of the Chicago, Rock Island & Pacific Ry., was seriously injured recently in collision between the taxi-cab in which he was riding and a street car in Chicago, Ill. Mr. Nettleton was alone and was taken to a hospital in an unconscious condition, and it was several days before his identify was established.

Mr. George E. Datesman, M. Am. Soc. C. E., Principal Assistant Engineer of the Bureau of Surveys, Philadelphia, Penn., sailed recently from New York City for Europe, where he expects to spend three months investigating the recent improvements in sewage-disposal works in England and on the continent. Mr. Datesman is sent by the City of Philadelphia, which under the recent state law will soon be obliged to stop the pollution of the Delaware and Schuylkill Rivers. It has been estimated that the proposed sewage-disposal works will cost $30,000,000 and require eight or ten years to build.

Mr. C. J. Smith, recently General Manager of the Richelieu & Ontario Navigation Co., has been made Vice-President and General Manager of the North Ry. and Hudson Bay Steamship Co., of Canada. This project has been subsidized by the Dominion Government and an extensive land grant has been made the company by the Government of the Province of Quebec. The railway has been surveyed between Montreal and James Bay and it is reported construction work will start soon. It is expected to complete the entire 500 miles of track in two years. Mr. Smith was born in Hamilton, Ont., in 1862, and has had an extensive railway experience in both Canada and the United States.

Messrs. Eugene E. Haskell, M. Am. Soc. C. E., Director of the college of civil engineering, Cornell University, William J. Stewart, M. Can. Soc. C. E., Chief Hydrographer, Department of Marine and Fisheries, Canada, and Victor F. W. Forneret, M. Can. Soc. C. E., Engineer-in-charge, St. Lawrence Ship Channel, have been appointed a commission to investigate the water levels on the St. Lawrence River, at and below Montreal, Que. The investigation is to be made under the direction of the Minister of Marine and Fisheries to determine the best means of obtaining and maintaining the proposed 35-ft. ship channel, and to determine the effect of the Chicago Drainage Canal on the St. Lawrence River levels.

Mr. Sylvester Q. Cannon, a Consulting, Mining and Hydraulic Engineer, of Salt Lake City, Utah, has been appointed City Engineer of Salt Lake City, succeeding Mr. D. H. Blossom, resigned, as noted in our issue of Mar. 27. Mr. Cannon graduated from the Massachusetts Institute of Technology in 1899. For a time he was in partnership with his two brothers in Salt Lake City. He then served as a missionary for the Mormon Church in Rotterdam, Holland. On his return to Salt Lake City, he was appointed to a position under the State Engineer of Utah and had charge of the hydrographic survey of the Weber River in 1905 and 1906. From 1906 to 1909 he served on another mission for the Mormon Church. Since 1909 he has been in private practice in Salt Lake City.

Mr. R. A. C. Smith, Chairman of the New York State Harbor Commission, has been appointed Commissioner of Docks of the City of New York, succeeding Mr. Calvin Tomkins, Assoc. Am. Soc. C. E., removed by Mayor Gaynor, as noted elsewhere. Mr. Smith is President of the American Mail Steamship Co., President of the North American Mail Steamship Co., President of the Oakland Bayside Realty Co., the Pelham Electric Light & Power Co., and the W. K. Niver Coal Co.; Vice-President of the Chicago Union Traction Co., a trustee of the American Surety Co., Chairman of the Executive Committee of the Westchester Lighting Co., a director of the American Tobacco Co., the Connecticut Railway & Lighting Co., H. deCamanas y Carbajal, the Havana Commercial Co., the Havana Tobacco C., the Holmes Electric Protective Co., the International Banking Corporation, the Interstate Tunnel Railway Co., the New Niquero Sugar Co., New York City Railway Co., Flint & Co., John Stephenson & Co. and the Plainfield Gas & Electric Light Co.

Mr. Calvin Tomkins, Assoc. Am. Soc. C. E., has been removed from the office of Commissioner of Docks, New York City, by Mayor Gaynor, because of a difference of opinion as to the proposed dock and pier improvements. An abstract of the statement Mr. Tomkins gave to the press on Apr. 4 is as follows:

> The two big things that brought about my removal were my fight against the New York Central R.R. Co.'s private development of Manhattan's waterfront, and the exploitation of South Brooklyn's waterfront by the Bush Terminal Co. Every indication now is that the private interests will supplant the public control of New York City's waterfront.
>
> I am unconditionally opposed to the recent policy of the Board of Estimate—whether adopted by choice or accepted for expediency—by which the great bulk of our profit-paying dock investment exemption ($50,000,000 out of $65,000,000) has been taken for subways and the development of a freight terminal system left for exploitation by private monopolies; the laws, by which but two years ago New York pledged herself to furnish modern port facilities at the lowest cost at which they could be made self-sustaining, and now so amended as to return to the old system under which our commerce has been charged "all it would bear" for public and private profit; and the limited fund left for the Dock Department, which it is planned to use to procure exclusive New York Central right-of-way and most expensive express steamship piers, instead of for the general extension of our commercial, dock and terminal system, including ample long pier provisions—[New York "Evening Post," Apr. 4.]